Effectiveness of an intervention programme on arm, shoulder and neck symptoms in computer workers

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BODY@WORK

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door
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geboren te Renkum

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'Wonder is the beginning of all wisdom'

....

Aristotle (384 BC – 322 BC)

Contents

CHAPTER **1** CHAPTER

General introduction

General Introduction

'I was 22 and working as a legal secretary when I first felt pain in my arms. I ignored it, thinking or hoping it would go away, and continued to work at my normal pace. I had recently changed jobs and didn't want to cause any problems. However, typing for six or seven hours a day I soon realized the pain was getting worse. I continued working for about six months, then my employer put me off work. It got to the stage that I couldn't type more than a few minutes at a time and couldn't keep up with the workload. They didn't have any light duties for me nor did they want to re-instate me unless I could type as much as I had done previously. In the end, they legally terminated my employment after I had been off work for six months.'
Kristina [1]

Historical perspective of work-related arm, neck and shoulder symptoms and computer work

Work-related arm, shoulder and neck symptoms, as experienced by Kristina above, have been known for centuries. The connection between arm, shoulder and neck symptoms and work was first documented by the Italian physician Ramazzini at the beginning of the 18th century [2]. In the 1713 revised edition of De Morbis Artificum, Ramazzini discusses diseases of scribes and notaries. He notes three classes of maladies associated with these occupations: those from constant sitting, constant writing, and mental strain from frequent tedious calculations. About the dangers of constant writing, Ramazzini says, 'An acquaintance of mine, a notary by profession, still living, used to spend his whole life continually engaged in writing, and he made a good deal of money from it; first he began to complain of intense fatigue in the whole arm, but no remedy could relieve this, and finally the whole right arm became completely paralyzed. In order to offset this infirmity he began to train himself to write with the left hand, but it was not very long before it too was attacked by the same malady [3].' Almost three hundred years later, similar symptoms still constitute a considerable problem. Also among the large population of computer workers, arm, shoulder and neck symptoms are highly prevalent [4].

The word 'computer' was first recorded in 1613, and at that time it referred to a person who carried out calculations, or computations. From the end of the 19th century onwards, the word began to take on its current meaning, describing a machine that carries out computations [5]. Over the past 30 years personal computers (PCs) have become increasingly common in both workplaces and homes. The number of PCs installed worldwide surpassed 1 billion units in 2008. Approximately 75% of these machines were used in the work environment, while the other 25% were for personal use. Worldwide growth was estimated at around 10 percent annually [6] and, according to

Gartner's PC installed base forecast, the total number of PCs in use will reach 1.78 billion units in 2013 [7].

Computer use is one of the most common workplace exposures in modern society. In 2008, a large survey was held among workers in the Netherlands. Almost 80% of the participating workers indicated that they worked a minimum of 1 hour per day with the computer, with an average (including those who did not work with the computer) of 3.8 hours per day. Workers who performed computer work did so during an average of 4.8 hours per day [8].

Terminology in this thesis

Work-related arm, shoulder and neck symptoms are currently described with a wide range of terms.

Next to Wii-itis [9], upper extremity disorders (UED), work-related upper extremity musculoskeletal disorders (WRUMD), cumulative trauma disorders (CTD) and repetitive strain injury (RSI) are used. In the Netherlands, arm, shoulder and neck symptoms are commonly called RSI and this is the primary reason why this umbrella term was used in the name of the intervention programme which is studied in this thesis. There are, however, valid arguments against the use of the term RSI. The cause of these symptoms is not necessarily the performance of repetitive movements, but can also be static load, nor need there be an injury. In this thesis, the term arm, shoulder and neck symptoms will primarily be used for self-reported discomfort or pain and the term disorder will be used when an occupational physician has made a diagnosis. With arm, shoulder and neck symptoms a broad range of musculoskeletal symptoms is meant, not necessarily with a common etiology.

Incidence, prevalence, trends and costs

Although it is still debated whether computer use in itself increases the risk of getting arm, shoulder and neck symptoms [10], a prospective study of computer users by Gerr et al. [11] showed that the occurrence of these symptoms is common among computer users, with more than 50% of computer users reporting symptoms during the first year after starting a new job. Luime and colleagues [12] observed 12-month incidence rates for neck and shoulder complaints of 16% and 18%, respectively. The 12-month prevalence rates were roughly twice as high, and 12-month recurrence rates were approximately twice the prevalence rates.

Although the incidence and recurrence rates for arm, shoulder and neck symptoms are high, results from the Netherlands Center for Occupational Diseases (NCvB), which registers and reports occupational diseases via the national notification and registration system, show that the number of registered occupational diseases in the arm, shoulder

and neck area has been declining steadily over the last six years [13]. This has provoked some debate in the Netherlands on the overall importance of arm, shoulder and neck symptoms in the workplace and the need for prevention efforts to reduce the number of workers with these symptoms. To gain more insight in the incidence trends of arm, shoulder and neck symptoms and sick leave as a result of these symptoms, we analyzed data from more than 17,000 organizations and companies in the Netherlands in the beginning of 2010. The data, collected by Arbo Unie, one of the largest occupational health services in the Netherlands, consisted mainly of computer workers who consulted their occupational physician. Results from the first quarters of 2007, 2008 and 2009, showed a small decline in the number of workers who were on sick leave due to arm, shoulder and neck symptoms over these three first quarters. However, contrary to the decline of number of registered sick leave cases, the total number of sick leave days as a result of these symptoms increased from 2007 to 2009. An explanation for this decline in registered workers with symptoms, but with more sick leave days per worker, might be that in a period of economic decline workers are hesitant to visit their occupational physician with minor symptoms. They decide to visit their occupational physician only when the symptoms are long-lasting. Therefore, data on the registered occupational diseases in the arm, shoulder and neck area should be interpreted with caution and there is still a need for preventive action to reduce symptoms and costs. The total yearly costs of arm, shoulder and neck symptoms in the Netherlands due to decreased productivity, sick leave, chronic disability for work and medical costs were estimated at 2.1 billion Euros [14]. Available estimates of musculoskeletal disorders from 15 European countries put the cost between 0.5% and 2% of their gross domestic products [15].

Risk factors

The health effects of computer work have been studied extensively over the last decades, but there is still much controversy on the question of whether the duration of computer work is indeed a risk factor for arm, shoulder and neck symptoms [10, 16-18]. While the duration of computer work itself may not necessarily be a risk factor, various ergonomic, psychosocial and organizational risk factors for arm, shoulder and neck symptoms have been suggested to increase the risk in computer workers [19]. The onset of such symptoms was suggested to be caused by exposure to a combination of these risk factors [19].

In 2003, we developed the RSI QuickScan questionnaire [20] with the objective to rapidly assess arm, shoulder and neck symptoms and risk factors in populations of computer workers. For this, a literature search was performed on potential risk factors for arm, shoulder and neck symptoms. A decision was made to include all major known risk factors for computer work at the time and, therefore, risk factors without conclusive evidence were also included. The background for this was, that we would rather receive information on a risk factor too many, than too few. Unnecessary questions could be

removed at a later date, when there was more clarity on the reliability and validity. This review of the literature, combined with input from professionals in the field, ultimately resulted in 13 potential risk factors that were included the questionnaire. These factors were: (lack off) education [21-25]; duration of computer work [4, 26, 27]; poor work posture and movement [27-30]; monotonous work tasks [31, 32]; low decision authority [33, 34]; adverse psychosocial work conditions [35, 36]; (psychosocial) job demands [37, 38]; recovery time [39]; substandard work environmental conditions (e.g. lighting, temperature and acoustic conditions) [40]; poorly designed furniture [25]; poor workstation physical attributes, such as a mouse or keyboard [41, 42]; visual strain and visual discomfort [43, 44], and arm, shoulder and neck symptoms [45-48]. The etiologic importance of occupational ergonomic stressors for the occurrence of arm, shoulder and neck disorders has been demonstrated [49] and reducing these risk factors might play a role in the prevention of future arm, shoulder and neck symptoms in a working population. It seems likely that arm, shoulder and neck symptoms are the result of exposure to many factors, including physical load and the psychosocial work environment, and that these factors may reinforce each other [19, 50].

Pathophysiology

As ergonomist working for a broad range of organizations, my experience is that some employers are reluctant to accept that computer work, in a nice and warm office, may cause disorders and symptoms and is worthy of prevention efforts. Also Kristina's employer may have thought so. Especially, in the more physically demanding working environments the notion that a light task such as clicking on a mouse or typing on a keyboard can be an occupational health risk, is being frowned upon.

This paragraph presents a concise overview of hypotheses on how exposure to the risk factors, as described above, might cause arm, shoulder and neck symptoms. The focus of this presentation is on the pathophysiology in muscle tissue, although other tissues, such as tendons, ligaments, joints, peripheral nerves, and supporting blood vessels may also be affected [51, 52].

During computer work, several upper extremity muscles are continuously active at around 10% of their maximum [53, 54]. The concept that this could cause (serious) symptoms has long been debated. However, there is evidence, mostly from animal experimental research, that low-intensity loading can result in muscle damage and, subsequently, arm, shoulder and neck symptoms, provided that the loading takes place over a longer period of time [55-58].

In a review of the scientific literature, Visser and Van Dieën (2006) reported several possible scenarios (partly) explaining why a relatively low level of muscle activity may lead to muscle disorders. The first and most relevant scenario includes the influential 'Cinderella hypothesis' (referring to Cinderella, the fairy-tale figure, who was first to

rise, worked all day and was the last to go to bed) [59]. This hypothesis assumes that the load of a muscle at sub-maximal levels, such as Kristina performed when typing for six or seven hours per day, is not homogeneously distributed among the muscle fibers. Only a fraction of the available motor units (a combination of the nerve cell and the muscle fibers it activates) are engaged. The muscle fibers are recruited in stereotypical order, depending on the size of the motor unit to which they belong. This so-called 'size principle' [60] implies that small motor units with type I fibers will remain continuously activated when lengthy tasks are performed. Gissel [56] suggested that continuous activation over a longer period of time results in a Ca^{2+} accumulation in muscle compartments, which may cause damage to the muscle fiber and, subsequently, lead to muscle disorders.

Johansson et al. [61] state that multiple mechanisms may interact in (series of) circular processes. Homeostatic disturbances in muscle tissue, resulting from muscle activity, can result in an accumulation of metabolites, stimulating nociceptors. This process can be enhanced in subjects with relatively large type I fibers and low capillarization, which paradoxically may have developed as an adaptation to the exposure. Nociceptor activation can disturb the proprioception [62, 63] and thereby the motor control, most likely leading to further increased muscle activity to be able to meet the task requirements and an associated increase in disturbance of muscle homeostasis. The pain resulting from nociceptor activity can cause increased sympathetic activity leading to decreased blood circulation and increased levels of muscle activity. In addition, in the long run a reduction of the pain threshold and an increase of pain sensitivity can develop. It is worth noting that initial nociceptor stimulation may be a response to metabolite accumulation preceding tissue damage [58].

As an effect modifier, psychosocial work characteristics, such as high mental load and job demands, may increase muscle tension and continuously activate certain muscle fibers. Low-intensity loading due to continuous firing of low threshold motor units is, therefore, not only due to physical loading, but may also be caused by mental loading [64, 65].

Besides the above mentioned theories, Deeney and O'Sullivan [66] present in their article on work-related psychosocial risks and musculoskeletal disorders, several other potential pathways to injury. One of these theories is the hyperventilation theory of job stress and work-related musculoskeletal disorders by Schleifer and Ley [67]. This theory suggests that psychosocial risks can cause emotional strain that might result in hyperventilation. Hyperventilation (overbreathing) refers to a drop in arterial CO_2 caused by ventilation that exceeds metabolic demands for O_2. Excessive loss of CO_2 that results from hyperventilation produces a rise in blood pH (i.e. respiratory alkalosis). This disruption in the acid–base equilibrium triggers a chain of systemic physiological reactions that have adverse implications for musculoskeletal health, including increased muscle tension, muscle spasm, amplified response to catecholamines, and muscle ischemia and hypoxia. Furthermore, hyperventilation is often characterized by a shift from a diaphragmatic to

a thoracic breathing pattern, which imposes biomechanical stress on the neck/shoulder region due to the recruitment of ancillary muscles (i.e. trapezius) in support of thoracic breathing [68].

According to the nitric oxide/oxygen ratio hypothesis presented by Eriksen [69], neck myalgia is evoked when low-level contractions in the trapezius muscle are combined with sympathetic vasoconstriction due to psychological stress or prolonged head-down neck flexion at work. These ischemic contractions increase nitric oxide/oxygen concentration ratio in the muscle fibers and a depletion of ATP. This would elicit production of lactic acid due to which nociceptive fibers would be activated, causing muscle pain.

There is growing evidence that psychosocial risk factors exacerbate the effects of physical risk factors thereby increasing the risk and severity of arm, shoulder and neck symptoms [66]. The aforementioned pathophysiological hypotheses provide valuable insight on how perceivably light tasks such as clicking on a mouse or typing on a keyboard, as performed by the 22 year old legal secretary Kristina, can indeed be an occupational health risk.

Effectiveness and cost-effectiveness of interventions

It is generally acknowledged that the costs of musculoskeletal disorders, considered from a company and societal perspective, are high and impose a heavy burden on employers and on society [70]. Aiming to reduce these costs, in the Netherlands two thirds of the organizations with more than 500 employees had implemented interventions to prevent arm, shoulder and neck symptoms in 2009 [71].

Although arm, shoulder and neck symptoms may be the result of many factors, including physical load and the psychosocial work environment, intervention studies are often aimed at one specific work-related factor, such as the duration of computer work, mouse use, the use of an adjustable chair, or single work-related psychosocial factors, such as insufficient recovery time and insufficient social support [72-75]. While moderate evidence for some interventions was found, no strong evidence for the effectiveness of interventions in reducing symptoms in occupational settings could be established [72-75]. A recent review by Driessen et al. [76] concluded that ergonomic interventions are usually not effective for preventing or reducing neck pain among non-sick listed workers.

A wide range of intervention approaches is available to address the hypothesized pathogenesis of arm, shoulder and neck symptoms. Some of the interventions are primarily aimed at physical risk factors, such as prolonged awkward posture, while other interventions are primarily aimed at psychosocial risk factors, such as emotional strain. These interventions involve different strategies to prevent the assumed underlying causes of these symptoms, such as prolonged increased muscle tension and low-intensity loading.

Despite the lack of effective interventions, employers and policy makers still implement interventions aimed at reducing the costs of musculoskeletal disorders. However, their funds are often limited and, as a consequence, there is a need to identify the most cost-effective interventions. Reliable information on both the costs and benefits of interventions is still largely lacking and, therefore, there is a demand for economic evaluations of interventions [77].

RSI QuickScan intervention programme

Interventions for the primary and secondary prevention of arm, shoulder and neck symptoms are usually aimed at the general population of computer workers, instead of workers with a high exposure to certain factors. Furthermore, interventions often do not address the most prominent risk factors. These two aspects might contribute to a limited effectiveness of interventions. Prevention efforts should ideally be targeted at specific populations with a high risk [78], as reducing a low exposure even further is unlikely to yield much effect. Moreover, interventions should ideally be tailor-made and aimed at the most prominent risk factors. To effectively reduce the prevalence of arm, shoulder and neck symptoms, exposure to risk factors and sick leave in computer workers, the RSI QuickScan intervention programme was developed (Figure 1).
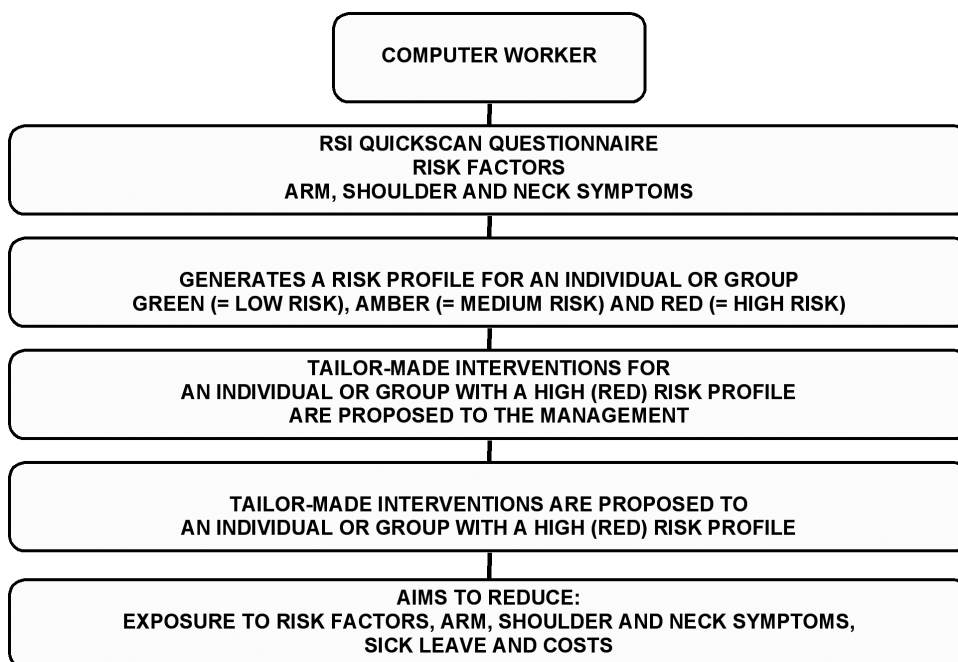
Figure 1. *Flowchart of the RSI QuickScan intervention programme for computer workers.*

This multidimensional intervention program starts with the internet-based RSI Quick-Scan questionnaire (Figure 2). This questionnaire assesses the presence or absence of exposure to potential risk factors for the establishment of risk profiles related to arm, shoulder and neck symptoms in computer workers, as already pointed out in the paragraph on risk factors above. The questionnaire consists of 12 sections on work (e.g. work hours, work tasks), work relation with management and colleagues, office ergonomics (e.g. furniture and computer workstation physical attributes) and one section on health (e.g. arm, shoulder and neck symptoms).

1

Figure 2. *Example of items in the RSI QuickScan questionnaire.*

Directly after completion of each section of the questionnaire the respondents receive feedback on their questionnaire results. This feedback consists of scores on a scale from 1 to 10 (with 10 being the optimal score), an interpretation of the score and advice on the specific actions that the respondents can take in order to reduce their risk of arm, shoulder and neck symptoms (Figure 3). In addition, a visual representation of the combined scores with a graph is provided (Figure 4).
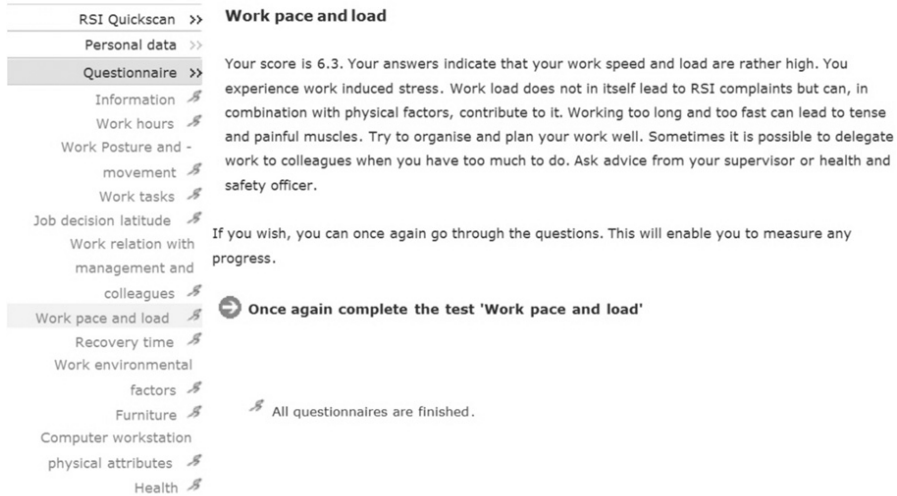
Figure 3. *Example of individual feedback on the questionnaire results.*
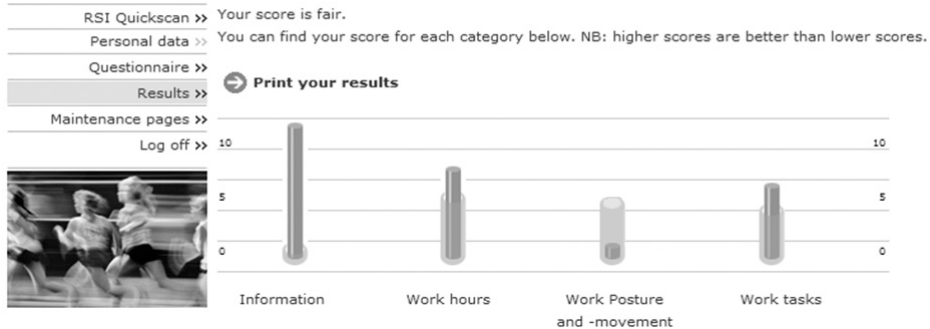
Figure 4. *Example of a visual representation of the individual questionnaire results.*

Furthermore, a risk profile is made on a group level from the information given by all respondents within an organization, a department or function group (Figure 5). A score of 30% or less of the maximum on a scale is classified as a low (green) risk. A score of 31% to 60% of the maximum on a scale is classified as a medium (amber) risk. A score of 61% or more of the maximum on a scale is classified as a high (red) risk.
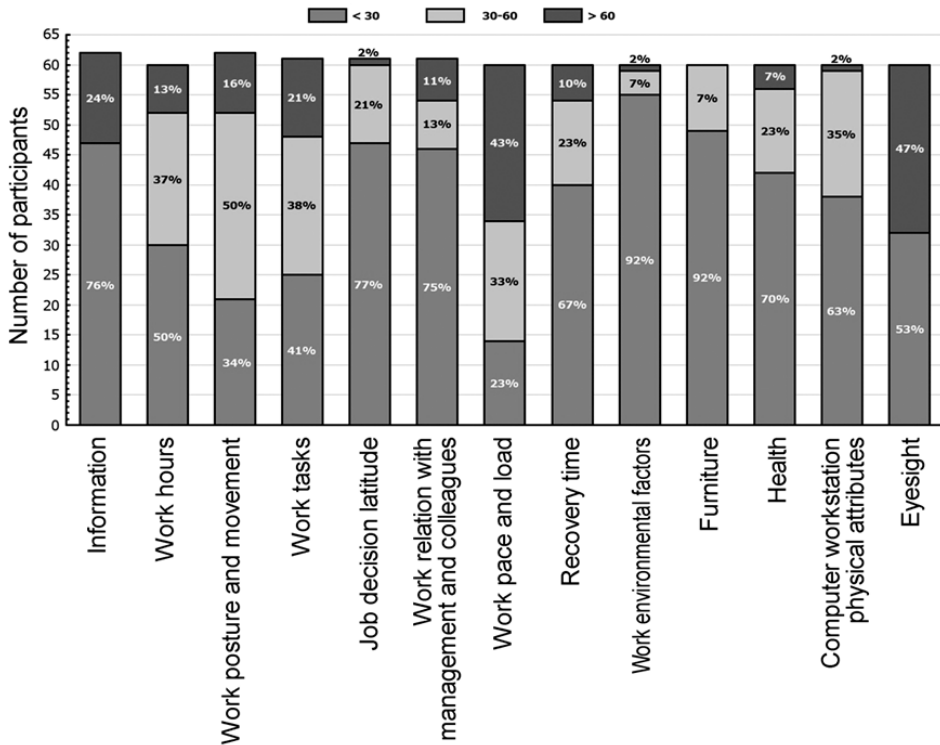
Figure 5. *Example of the questionnaire results on a group level.*

If more than 30% of the participants has a red score, or more than 60% of the participants has a red or amber score, a tailor-made intervention programme is proposed. Per scale a (set of) intervention(s) to be advised was pre-defined. Depending on their risk profile, some workers are offered multiple interventions. Interventions are carried out both on an individual and a group level. Examples of proposed interventions, on an individual level, are an individual workstation check, an eyesight check, or a visit to the occupational physician. On a group level, an education programme on the prevention of arm, shoulder and neck symptoms for employees, or a training aimed at handling stress in the workplace can be mentioned as examples. The RSI QuickScan intervention programme is primarily aimed at primary and secondary prevention of arm, shoulder and neck symptoms. The interventions are classified as primary or secondary prevention, according to the undermentioned definition. In this thesis, the three important tiers within occupational health prevention are defined as follows:

1. **Primary prevention:** Primary prevention represents interventions that are aimed at healthy workers and the workplace. The goal of these interventions is to avoid the onset of arm, shoulder and neck symptoms.

2. **Secondary prevention:** Secondary prevention represents interventions that are aimed at early symptomatic workers and the workplace. The goal of these interventions is to eliminate or reduce exposure in order to prevent chronic arm, shoulder and neck symptoms.

3. **Tertiary prevention:** Tertiary prevention represents interventions that are aimed at workers with chronic symptoms and the workplace. The goal of these interventions is to reduce further exposure, minimize additional loss of arm, shoulder and neck function, and minimize the social, economic and quality of life impacts.

The RSI QuickScan intervention programme is quite unique in that it incorporates many different aspects, addressing a broad spectrum of potential risk factors. Instead of using generic strategies, which is common among occupational health services in the Netherlands, this method establishes a risk profile of the target population and subsequently advises interventions following a decision tree based on that risk profile.

Objectives

The objective of this thesis is to assess the reliability, consistency and validity of the RSI QuickScan questionnaire and the (cost-) effectiveness of the RSI QuickScan intervention programme on the prevalence of arm, shoulder and neck symptoms, exposure to risk factors, and sick leave in a population of computer workers.

Study questions

The questions that will be answered are:

1. Is the RSI QuickScan questionnaire for computer workers reliable, consistent and valid?
2. Is the RSI QuickScan intervention programme effective in reducing the prevalence of arm, shoulder and neck symptoms, exposure to risk factors, and sick leave in a population of computer workers?
3. Is the RSI QuickScan intervention programme for computer workers cost-effective?

Study design and outline of this thesis

The study design and the outline of this thesis are visualized in figure 6. First, the results of the validation study are described in chapters 2 and 3. In chapter 2, a study on the internal consistency, test-retest reliability and concurrent validity of the questions on work-related exposure related to arm, shoulder and neck symptoms in computer workers is presented. In chapter 3, a study on the concurrent validity of the symptom questions in the questionnaire is described. In chapter 4, a study on the predictive validity of the RSI QuickScan questionnaire with respect to the prevalence of arm, shoulder and neck symptoms in computer workers is presented. The effectiveness and cost-effectiveness of the RSI QuickScan intervention programme was studied in a cluster randomized

controlled trial (RCT) in an occupational setting. In chapter 5, the effectiveness of the RSI QuickScan intervention programme on the prevalence of arm, shoulder and neck symptoms, risk factors and sick leave in computer workers is described. In chapter 6, the cost-effectiveness and cost-benefits of the RSI QuickScan intervention programme are studied in an economic evaluation. In chapter 7, a general discussion, with conclusions and recommendations, is presented.
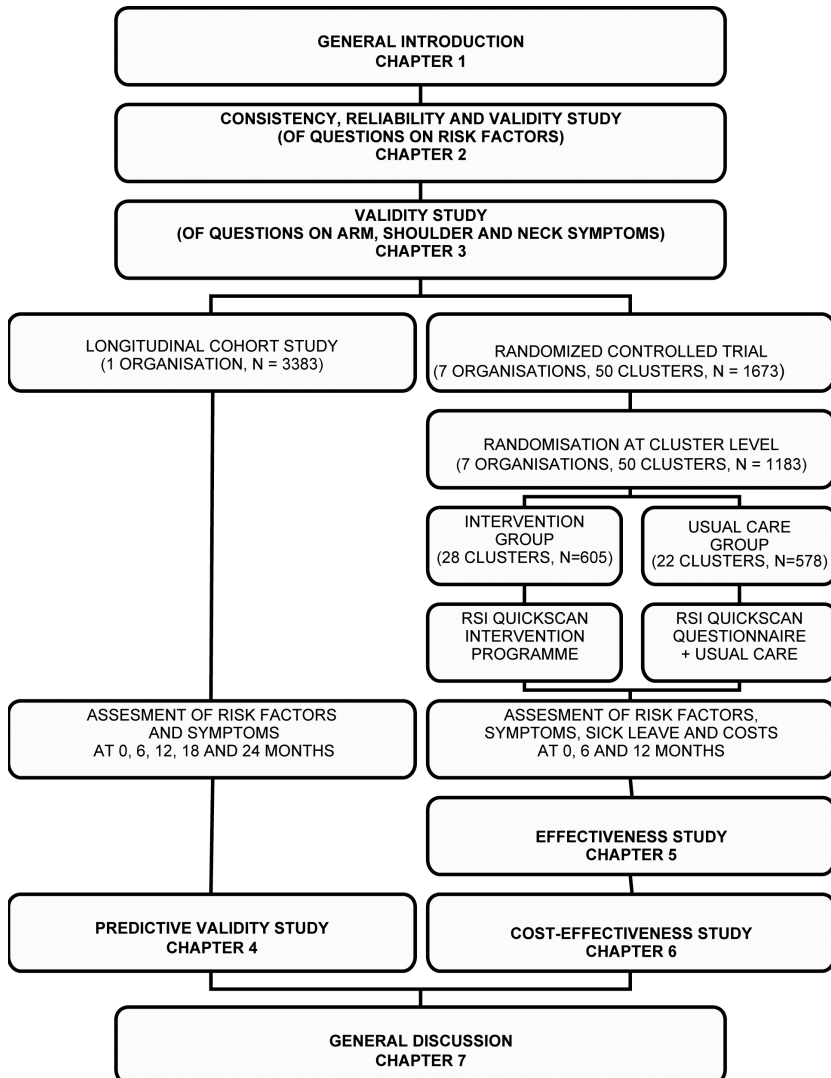
Figure 6. *A schematic overview of the study design and the different studies in this thesis with the position of the seven chapters.*

References

[1] **Kristina.** *Early signs. RSI and Overuse Injury Association of the ACT 2010 [cited 2010 Nov 10]; Available from: http://www.rsi.org.au*

[2] **Rammazzini B.** *Diseases of the Workers (De Morbis Artificum Diariba, 1713) [Wright WC, translator]. New York: Hafner 1964.*

[3] **Altschuler EL.** *Ramazzini and writer's cramp. Lancet. 2005;365(9463):938.*

[4] **Wahlstrom J.** *Ergonomics, musculoskeletal disorders and computer work. Occupational Medicine (Lond). 2005;55(3):168-76.*

[5] **Simpson J, Weiner E.** *Oxford English Dictionary. Oxford English Dictionary. 2nd ed. Oxford: Oxford University Press 1989.*

[6] **Gartner.** *Gartner Says More than 1 Billion PCs In Use Worldwide and Headed to 2 Billion Units by 2014. Stamford, Connecticut 2008.*

[7] **Gartner.** *Gartner Highlights Key Predictions for IT Organizations and Users in 2010 and Beyond. Stamford, Connecticut 2010.*

[8] **Klein Hesselink J, Houtman I, Hooftman W, Bakhuys Roozeboom M.** *Arbobalans. Hoofddorp: TNO; 2009.*

[9] **Rubin D.** *Triad of spinal pain, spinal joint dysfunction, and extremity pain in 4 pediatric cases of "Wii-itis": a 21st century pediatric condition. 2010;9(2):84-9.*

[10] **Andersen JH, Harhoff M, Grimstrup S, Vilstrup I, Lassen CF, Brandt LPA, Kryger AI, Overgaard E, Hansen KD, Mikkelsen S.** *Computer mouse use predicts acute pain but not prolonged or chronic pain in the neck and shoulder. Occupational and Environmental Medicine. 2008;65(2):126-31.*

[11] **Gerr F, Marcus M, Ensor C, Kleinbaum D, Cohen S, Edwards A, Gentry E, Ortiz DJ, Monteilh C.** *A prospective study of computer users: I. Study design and incidence of musculoskeletal symptoms and disorders. American Journal of Industrial Medicine. 2002;41(4):221-35.*

[12] **Luime JJ, Koes BW, Miedema HS, Verhaar JAN, Burdorf A.** *High incidence and recurrence of shoulder and neck pain in nursing home employees was demonstrated during a 2-year follow-up. Journal of clinical epidemiology. 2005;58(4):407-13.*

[13] **Van der Molen H, Spreeuwers D, Kuijer P, Nieuwenhuijsen K, Bakker J, Pal T, Sorgdrager B, Van der Laan G, Stinis H, Brand T.** *Occupational diseases in Figures 2009. Amsterdam: Netherlands Center for Occupational Diseases (NCvB) - The Coronel Institute for Occupational Environmental Health - AMC UvA; 2010.*

[14] **Blatter BM, Houtman I, Van den Bossche S, Kraan K, Van den Heuvel S.** *Gezondheidsschade en kosten als gevolg van RSI en psychosociale arbeidsbelasting in Nederland [Health damage and costs of RSI and psychosocial work load in the Netherlands]: Report on demand of The Dutch Ministry of Social Affairs and Employment. TNO Quality of Life; 2005.*

[15] **European Commission.** *First-phase consultation of the social partners on musculoskeletal disorders at work, available online at: http://ec.europa.eu/employment_ social/news/2004/nov/musculoskeletaldisorders_ en.pdf. Brussels; 2004.*

[16] **Waersted M, Hanvold T, Veiersted KB.** *Computer work and musculoskeletal disorders of the neck and upper extremity: A systematic review. BMC Musculoskeletal Disorders. 2010;11(1):79.*

[17] **IJmker S, Huysmans MA, Van der Beek AJ, Knol DL, Van Mechelen W, Bongers PM, Blatter BM.** *Software-recorded and self-reported duration of computer use in relation to the onset of severe arm-wrist-hand pain and neck-shoulder pain. Occupational and Environmental Medicine. 2010;PMID: 21045214.*

[18] **IJmker S, Huysmans MA, Blatter BM, Van der Beek AJ, Van Mechelen W, Bongers PM.** *Should office workers spend fewer hours at their computer? A systematic review of the literature. Occupational and Environmental Medicine. 2007;64(4):211-22.*

[19] **Bongers PM, IJmker S, Van den Heuvel S, Blatter BM.** *Epidemiology of work related neck and upper limb problems: Psychosocial and personal risk factors (Part I) and effective interventions from a bio behavioural perspective (Part II). Journal of Occupational Rehabilitation. 2006;16(3):272-95.*

[20] **Speklé EM, Hoozemans MJM, Van der Beek AJ, Blatter BM, Bongers PM, Van Dieën JH.** *Internal consistency, test-retest reliability and concurrent validity of a questionnaire on work-related exposure related to arm, shoulder and neck symptoms in computer workers. Ergonomics. 2009;52(9):1087-103.*

[21] **Innes E.** *Education and training programs for the prevention of work injuries: do they work? Work. 1997;9:221-32.*

[22] **Rempel DM, Harrison RJ, Barnhart S.** *Work-Related Cumulative Trauma Disorders of the Upper Extremity. JAMA: The Journal of the American Medical Association. 1992;267(6):838-42.*

[23] **Street SL, Kramer JF, Harburn KL, Hansen R, MacDermid JC.** *Changes in postural risk and general health associated with a participatory ergonomics education program used by heavy video display terminal users: A pilot study. Journal of Hand Therapy. 2003;16(1):29-35.*

[24] **Bohr PC.** *Efficacy of Office Ergonomics Education. Journal of Occupational Rehabilitation. 2000;10(4):243-55.*

[25] **Amick III BC, Robertson MM, DeRango K, Bazzani L, Moore A, Rooney T, Harrist R.** *Effect of Office Ergonomics Intervention on Reducing Musculoskeletal Symptoms. Spine. 2003;28(24):2706-11.*

[26] **Punnett L, Bergqvist U.** *Visual Display Unit Work and Upper Extremity Musculoskeletal Disorders: A Review of Epidemiological Findings. Arbete och Hällsa. 1997;16:1-161.*

[27] **Gerr F, Marcus M, Monteilh C.** *Epidemiology of musculoskeletal disorders among computer users: lesson learned from the role of posture and keyboard use. Journal of Electromyography & Kinesiology. 2004;14:25-31.*

[28] **Aarås A, Dainoff M, Ro O, Thoresen M.** *Can a More Neutral Position of the Forearm When Operating a Computer Mouse Reduce the Pain Level for Visual Display Unit Operators? A Prospective Epidemiological Intervention Study: Part II. International Journal of Human-Computer Interaction. 2001;13(1):13-40.*

[29] **Cook C, Burgess-Limerick R, Papalia S.** *The effect of upper extremity support on upper extremity posture and muscle activity during keyboard use. Applied Ergonomics. 2004;35(3):285-92.*

[30] **Conlon CF, Krause N, Rempel DM.** *A randomised controlled trial evaluating an alternative mouse and forearm support on upper body discomfort and musculoskeletal disorders among engineers. Occupational and Environmental Medicine. 2008;65(5):311-8.*

[31] Harkness EF, Macfarlane GJ, Nahit ES, Silman AJ, McBeth J. *Mechanical and psychosocial factors predict new onset shoulder pain: a prospective cohort study of newly employed workers. Occupational and Environmental Medicine. 2003;60(11):850-7.*

[32] Juul-Kristensen B, Jensen C. *Self-reported workplace related ergonomic conditions as prognostic factors for musculoskeletal symptoms: the "BIT" follow up study on office workers. Occupational and Environmental Medicine. 2005;62(3):188-94.*

[33] Ariëns GAM, Bongers PM, Hoogendoorn WE, Houtman ILD, Van der Wal GMD, Van Mechelen W. *High Quantitative Job Demands and Low Coworker Support As Risk Factors for Neck Pain: Results of a Prospective Cohort Study. Spine. 2001;26(17):1896-901.*

[34] Ariëns GAM, Van Mechelen W, Bongers PM, Bouter LM, Van der Wal G. *Psychosocial risk factors for neck pain: A systematic review. American Journal of Industrial Medicine. 2001;39(2):180-93.*

[35] Toomingas A, Theorell T, Michelsen H, Nordemar R. *Associations between self-rated psychosocial work conditions and musculoskeletal symptoms and signs. Scandinavian Journal of Work, Environment & Health. 1997;23(2):130-9.*

[36] Houtman IL, Bongers PM, Smulders PG, Kompier MA. *Psychosocial stressors at work and musculoskeletal problems. Scandinavian Journal of Work, Environment & Health. 1994;20(2):139-45.*

[37] Hughes LE, Babski-Reeves K, Smith-Jackson T. *Effects of psychosocial and individual factors on physiological risk factors for upper extremity musculoskeletal disorders while typing. Ergonomics. 2007;50(2):261-74.*

[38] Bongers PM, Kremer AM, Ter Laak J. *Are psychosocial factors, risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist?: A review of the epidemiological literature. American Journal of Industrial Medicine. 2002;41(5):315-42.*

[39] Sluiter JK, De Croon EM, Meijman TF, Frings-Dresen MHW. *Need for recovery from work related fatigue and its role in the development and prediction of subjective health complaints. Occupational and Environmental Medicine. 2003;60(suppl 1):i62-i70.*

[40] Korhonen T, Ketola R, Toivonen R, Luukkonen R, Hakkanen M, Viikari-Juntura E. *Work related and individual predictors for incident neck pain among office employees working with video display units. Occupational and Environmental Medicine. 2003;60(7):475-82.*

[41] Straker L, Pollock C, Frosh A, Aarås A, Dainoff M. *An Ergonomic Field Comparison of a Traditional Computer Mouse and a Vertical Computer Mouse in Uninjured Office Workers. Human Factors and Ergonomics Society Annual Meeting Proceedings. 2000;44:356-9.*

[42] Tittiranonda P, Rempel D, Armstrong TJ, Burastero S. *Effect of four computer keyboards in computer users with upper extremity musculoskeletal disorders. American Journal of Industrial Medicine. 1999;35(6):647-61.*

[43] Woods V. *Musculoskeletal disorders and visual strain in intensive data processing workers. Occupational Medicine (Lond). 2005;55(2):121-7.*

[44] Aarås A, Horgen G, Bjørset H-H, Ro O, Thoresen M. *Musculoskeletal, visual and psychosocial stress in VDU operators before and after multidisciplinary ergonomic interventions. Applied Ergonomics. 1998;29(5):335-54.*

[45] Juul-Kristensen B, Sogaard K, Stroyer J, Jensen C. *Computer users' risk factors for developing shoulder, elbow and back symptoms. Scandinavian Journal of Work, Environment & Health. 2004;30:390-8.*

[46] Descatha A, Chastang JF, Cyr D, Leclerc A, Roquelaure Y, Evanoff B. *Do workers with self-reported symptoms have an elevated risk of developing upper extremity musculoskeletal disorders three years later? Occupational and Environmental Medicine. 2008;65(3):205-7.*

[47] Nordlund A, Ekberg K. *Self reported musculoskeletal symptoms in the neck/shoulders and/or arms and general health (SF-36): eight year follow up of a case-control study. Occupational and Environmental Medicine. 2004;61(3):e11-e.*

[48] Silverstein BA, Viikari-Juntura E, Fan ZJ, Bonauto DK, Bao S, Smith C. *Natural course of nontraumatic rotator cuff tendinitis and shoulder symptoms in a working population. Scandinavian Journal of Work, Environment & Health. 2006;32(2):99-108.*

[49] Punnett L, Wegman DH. *Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. Journal of Electromyography & Kinesiology. 2004;14:13-23.*

[50] Van der Windt DAWM, Thomas E, Pope DP, De Winter AF, Macfarlane GJ, Bouter LM, Silman AJ. *Occupational risk factors for shoulder pain: a systematic review. Occupational and Environmental Medicine. 2000;57(7):433-42.*

[51] Keller K, Corbett J, Nichols D. *Repetitive strain injury in computer keyboard users: Pathomechanics and treatment principles in individual and group intervention. Journal of Hand Therapy. 1998;11(1):9-26.*

[52] Sluiter JK, Rest KM, Frings-Dresen MHW. *Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders. Scandinavian Journal of Work, Environment & Health. 2001;27:1-102.*

[53] Zennaro D, Läubli T, Krebs D, Klipstein A, Krueger H. *Continuous, intermitted and sporadic motor unit activity in the trapezius muscle during prolonged computer work. Journal of Electromyography and Kinesiology. 2003;13(2):113-24.*

[54] Thorn S, Forsman M, Zhang Q, Taoda K. *Low-threshold motor unit activity during a 1-h static contraction in the trapezius muscle. International Journal of Industrial Ergonomics. 2002;30(4-5):225-36.*

[55] Lexell J, Jarvis J, Downham D, Salmons S. *Quantitative morphology of stimulation-induced damage in rabbit fast-twitch skeletal muscles. Cell and Tissue Research. 1992;269(2):195-204.*

[56] Gissel H. *Ca2+ accumulation and cell damage in skeletal muscle during low frequency stimulation. European Journal of Applied Physiology. 2000;83(2):175-80.*

[57] Barbe MF, Barr AE, Gorzelany I, Amin M, Gaughan JP, Safadi FF. *Chronic repetitive reaching and grasping results in decreased motor performance and widespread tissue responses in a rat model of MSD. Journal of Orthopaedic Research. 2003;21(1):167-76.*

[58] Visser B, Van Dieën JH. *Pathophysiology of upper extremity muscle disorders. Journal of Electromyography and Kinesiology. 2006;16(1):1-16.*

2

[59] **Hägg GM.** *Lack of relation between maximal force capacity and muscle disorders caused by low level static loads: a new explanation model. In: Queinnec Y, Daniellou F, editors. Proceedings of the 11th congress of the International Ergonomics Association; 1991; Paris: Taylor and Francis; 1991. p. 9-11.*

[60] **Henneman E, Somjen G, Carpenter DO.** *Excitability and inhibitibility of motoneurons of different sizes. Journal of Neurophysiology. 1965;28(3):599-620.*

[61] **Johansson H, Arendt-Nielsen L, Bergenheim M, Djupsjöbacka M, Gold JE, Johansson H, Ljubisavljevic M, Mano T, Matre DA, Passatore M, Punnett L, Roatta S, Van Dieën JH, Windhorst U.** *Chronic Work-related Myalgia. Neuromuscular Mechanisms Behind Work-related Chronic Muscle Syndromes. Gävle, Sweden: University Press 2003.*

[62] **Huysmans M, Hoozemans M, Van der Beek A, De Looze M, Van Dieën J.** *Position sense acuity of the upper extremity and tracking performance in subjects with non-specific neck and upper extremity pain and healthy controls. Journal of Rehabilitation Medicine. 2010;42:876-83.*

[63] **Van Oostrom S, Huysmans M, Hoozemans M, Van Dieën J.** *Verminderde proprioceptie bij RSI. Nederlands Tijdschrift voor Fysiotherapie. 2007;117(2):49-53.*

[64] **Westgaard R.** *Effects of physical and mental stressors on muscle pain. Scandinavian Journal of Work, Environment & Health. 1999;25(Suppl 4):19-24.*

[65] **Sjøgaard G, Lundberg U, R K.** *The role of muscle activity and mental load in the development of pain and degenerative processes at the muscle cell level during computer work. European journal of applied physiology. 2000;83(2-3):99-105.*

[66] **Deeney C, O'Sullivan L.** *Work related psychosocial risks and musculoskeletal disorders: Potential risk factors, causation and evaluation methods. Work: A Journal of Prevention, Assessment and Rehabilitation. 2009;34(2):239-48.*

[67] **Schleifer L, Ley R, Spalding T.** *A hyperventilation theory of job stress and musculoskeletal disorders. American Journal of Industrial Medicine. 2002;41(5):420-32.*

[68] **Schleifer L, Ley R.** *End-tidal Pco2 as an index of psychophysiological activity under high and low data-entry workload demands. Biological Psychology. 1995;41(1):99-100.*

[69] **Eriksen W.** *Linking work factors to neck myalgia: the nitric oxide/oxygen ratio hypothesis. Medical hypotheses. 2004;62(5):721-6.*

[70] **National Research Council IoM.** *Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities. Washington, D.C.: National Academy Press 2001.*

[71] **MarketConcern VS.** *BedrijfsgezondheidszorgMonitor 2009 [Occupational Health Service Monitor 2009]. Zaltbommel: Intomart/GfK; 2010.*

[72] **Boocock MG, McNair PJ, Larmer PJ, Armstrong B, Collier J, Simmonds M, Garrett N.** *Interventions for the prevention and management of neck/upper extremity musculoskeletal conditions: a systematic review. Occupational and Environmental Medicine. 2007;64:291-303.*

[73] **Brewer S, Van Eerd D, Amick III BC, Irvin E, Daum KM, Gerr F, Moore JS, Cullen K, Rempel D.** *Workplace interventions to prevent musculoskeletal and visual symptoms and disorders among computer users: a systematic review. Journal of Occupational Rehabilitation. 2006;16:325-58.*

[74] **Verhagen AP, Karels C, Bierma-Zeinstra SMA, Feleus A, Dahaghin S, Burdorf A, Koes BW.** *Exercise proves effective in a systematic review of work-related complaints of the arm, neck, or shoulder. Journal of Clinical Epidemiology. 2007;60(2):110.e1-.e14.*

[75] **Blatter BM, Bongers PM, Van Dieën JH, Van Kempen PM, De Kraker H, Miedema H, Reijneveld CN, De Vet HCW.** *RSI measures: prevention, treatment and return to work. [RSI-maatregelen: preventie, behandeling en reïntegratie]. The Hague: Ministry of Social Affairs and Employment; 2004.*

[76] **Driessen MT, Proper KI, Van Tulder MW, Anema JR, Bongers PM, Van der Beek AJ.** *The effectiveness of physical and organisational ergonomic interventions on low back pain and neck pain: a systematic review. Occupational and Environmental Medicine. 2010;67:277-85.*

[77] **Bongers PM.** *Why is the information on cost effectiveness of interventions to manage neck and upper limb symptoms still lacking, while all stakeholders would benefit from this information? Occupational and Environmental Medicine. 2007;64(5):289-90.*

[78] **Staal JB, de Bie RA, Hendriks EJM.** *Aetiology and management of work-related upper extremity disorders. Best Practice & Research Clinical Rheumatology. 2007;21(1):123-33.*

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CHAPTER **2** CHAPTER

Internal consistency, test-retest reliability and concurrent validity of a questionnaire on work-related exposure related to arm, shoulder and neck symptoms in computer workers

Abstract

Introduction: The aim of this study was to determine the internal consistency, test-retest reliability and concurrent validity of the RSI QuickScan, a newly developed questionnaire that aims to identify the presumed risk factors for arm, shoulder and neck symptoms in a population of computer workers.

Methods: The internal consistency was calculated using item analysis. The test-retest reliability and concurrent validity were analyzed by calculating the percentage of agreement, Cohen's Kappa and the Ppositive and Pnegative. The concurrent validity was also tested by comparing the results from the new questionnaire with those from the original questionnaires the questionnaire was based on, on-site expert observations and direct measurements.

Results: The results indicate that the RSI QuickScan is a measurement tool with acceptable internal consistency, reliability and concurrent validity.

Conclusions: The questionnaire can be used as a means to rapidly collect data on a large population of office workers and at low cost.

Introduction

The proportion of people working with a computer has increased over the years and is still rising. In 2006, more than three out of four workers in the Netherlands used a computer at their workplace, with an average of almost 4 hours per working day [1]. Data on 15 European countries showed that not only computer use has risen across Europe, with more people using computers all the time, but also work intensity, with rising numbers of people working at high speed and to tight deadlines [2]. Work-related arm, shoulder and neck symptoms occur frequently amongst computer workers. The 12-month prevalence of these symptoms in the general working population of the Netherlands was estimated at 28% [3]. Worker absence resulting from work-related arm, shoulder and neck symptoms was estimated at 3.0-6.2% of the total sick leave [4]. The same study showed that this sick leave combined with reduced productivity constitutes a significant financial burden for employers, estimated at 1.7 billion Euros per year. A recent study amongst computer workers with neck/shoulder or hand/arm symptoms shows that productivity loss is more often caused by a decreased performance at work than by sickness absence [5].

The widespread and increasing use of computers has generated an increasing interest in the effect of computer work on arm, shoulder and neck symptoms. Marcus et al. [6], for example, found that prolonged computer work (> 20 h per.week.) increases the risk of getting hand/arm symptoms and disorders 2.2 times. Furthermore, in a study by Gerr et al. [7], over half of the computer users reported arm, shoulder and neck symptoms after starting a new job. Several specific risk factors have been suggested, such as the duration of computer work [8-10], mouse use [6, 11-13], and hand posture, e.g. ulnar deviation greater than 20º [14]. Based on studies with objective measures of computer use, the debate is still ongoing regarding the strength of the evidence to support the hypothesis that computer work is an occupational risk factor for arm, shoulder and neck symptoms [8, 11].

Risk factors for arm, shoulder and neck symptoms are not limited to work-related physical exposure alone [15-17]. Personal characteristics and work-related psychosocial factors, such as insufficient recovery time, psychological burdens (high work pressure, high work stress, high work pace and work with high mental demands) and insufficient social support (relation with colleagues, superiors and management), have also been mentioned as risk factors [15, 18, 19].

Around 85% of the employers in the Netherlands use the services of a certified occupational health service. Their services aim at promoting safety, health and well-being in the workplace and thus limiting sick leave. In the prevention of arm, shoulder and neck symptoms, these occupational health services usually resort to generic strategies rather than targeting the specific risk profile of the population at hand. Since the cause

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of arm, shoulder and neck symptoms can vary from mainly physical, to psychosocial and personal factors, or a combination of all of the above, generic strategies might not address the problem effectively. Reliable and valid information concerning the presence of potential risk factors could be used to create a risk profile for the population of workers concerned. A method aimed at establishing such risk profiles followed by a decision tree for selecting the most appropriate interventions based on this profile may allow effective prevention of arm, shoulder and neck symptoms.

To assess the presence or absence of potential risk factors for the establishment of risk profiles related to arm, shoulder and neck symptoms in computer workers the present authors developed an Internet-based questionnaire (RSI QuickScan), which consists of several topics on work and office ergonomics (Appendix 1). In total, the questionnaire consists of 81 items, divided over two categories and 11 subcategories (Appendix 1). (A description of the actual questions studied can be found at: *http://www.rsiquickscan.com/research/validity/*).

Theoretical models, such as the model of workload presented by Van Dijk et al. [20] and the demand-control-support model of Karasek and Theorell [21], have contributed to developing this questionnaire. The questions were constructed or selected on the basis of an analysis of the literature on arm, shoulder and neck symptoms and discussions with experts in the field. A substantial part of the questions on "work" in the RSI QuickScan was derived from the previously validated questionnaire on musculoskeletal load and health complaints (VBA), [22] and the Dutch Musculoskeletal Questionnaire (DMQ) by Hildebrandt et al. [23]. Since the target population, which consists solely of computer workers, is different from the original general working population that was used for validating the VBA and DMQ, a new validation was required.

An advantage of assessment using questionnaires is that data on a large population can be collected in a short period of time and at low cost. However, a disadvantage of questionnaires is that the collected data may be of limited quality [24, 25]. Recent studies, nevertheless, have reported the measurement properties of an upper extremity-specific self-report index of ergonomic exposures to be sufficient [26, 27]. A systematic review by Stock et al. [28] also showed that the outcomes of questionnaires on physical work demands corresponded well to observations and direct measurements. Therefore, the aim of this study was to determine the internal consistency, test-retest reliability and concurrent validity of a newly developed comprehensive questionnaire for use in an occupational health setting.

Methods

Internal Consistency Study

To study the internal consistency of the RSI QuickScan questionnaire, a population of 86 computer workers was asked to fill out the questionnaire. The participants were invited by email to fill out the Internet-based questionnaire. If they did not respond, they automatically received a reminder by email after 2 and 3 weeks. For this study, the Dutch version of the questionnaire was used.

The 86 computer workers were employees of a local government office (personnel department) and an Occupational Health Service (office staff), of which 70 (81%) were females and 16 (19%) were males. The educational level of this population was primarily intermediate to higher vocational, or university education. The age of the population was mostly (74%) between 40 and 59 years old; 26% of the population was between 20 and 39 years old. There were no employees under 20 or over 60 years. In total, 64 (74%) participants filled out the questionnaire.

The internal consistency was calculated using item analysis. The extent in which the items as a total are associated was expressed in the internal consistency index alpha (also Cronbach's alpha). A Cronbach's alpha value of at least 0.70 was considered to be acceptable. Cronbach's alpha was calculated using SPSS version 14 [29].

Reliability Study

The test-retest reliability of the RSI QuickScan was investigated simultaneously with the study of the internal consistency. The study population is therefore the same as described above. To study the test-retest reliability of the RSI QuickScan questionnaire, the computer workers were asked to fill out the questionnaire twice, with a 4 week interval. In total, 64 (74%) participants filled out the first questionnaire and 55 (64%) participants filled out the second questionnaire. A total of 53 (62%) participants filled out both questionnaires.

Most questions (70%) of the RSI QuickScan had dichotomous, risk or no risk, response categories; those that did not were dichotomized into a risk and a no risk category. The test-retest reliability was analyzed by calculating the percentage of agreement and Cohen's Kappa with 95% CI for each of the 81 questions.

Since the percentage of agreement and Cohen's Kappa show no insight in the agreement between the positive and negative answers, Ppositive and Pnegative were also calculated as extra means of assessing the agreement [30].

Concurrent Validity Study

Concurrent validity of the questionnaire

The concurrent validity of the questionnaire, with the exception of the questions on workstation characteristics, was tested among 73 computer workers working at the personnel department of a college. There is no overlap between these subjects and the subjects in the internal consistency and reliability studies. This population had to fill out the RSI QuickScan questionnaire as well as the original questionnaires on which the new questionnaire was based, with a 4-week interval. Of the 73 workers, 38 (52%) were females and 35 (48%) were males. The educational level of this population was primarily higher vocational or university education. Half of the population was between 20 and 39 years old; 45% of the population was between 40 and 59 years old and 5% of the employees were under 20 or over 60 years. In total, 59 (81%) participants responded to the RSI QuickScan questionnaire and 55 (75%) participants filled out the original questionnaire. A total of 51 (70%) participants filled out both questionnaires.

The concurrent validity of the questions on workstation characteristics.

The concurrent validity of the questions on workstation characteristics was tested by comparing questionnaire results with on-site expert observations and direct measurements of the workplace among a population of 73 computer workers of an occupational health service. From this population, a total of 54 (74%) computer workers, of which 41 (76%) were females and 13 (24%) were males, participated in the on-site expert observations and direct measurements. The educational level of this population was primarily higher vocational or university education. Approximately half (51%) of the population was between 20 and 39 years old and the other half (49%) was between 40 and 59 years old. There were no employees under 20 or over 60 years.

To validate 15 questions on the physical aspects of the workstation, derived from the scales 'furniture' and 'computer workstation physical attributes' (Appendix 1), a workstation assessment was carried out. Answers given by the computer worker when filling out the RSI QuickScan approximately 4 weeks previously were compared to answers on the same questions obtained from on-site expert observation and direct measurements. The on-site observations were carried out by two trained observers according to a standardized procedure and checklist (Appendix 2) (the checklist can be found at: *http://www.rsiquickscan.com/research/validity/*), which resulted in dichotomous, risk or no risk, scores. The observers were not given the questionnaire results prior to their assessment. The observations were practiced several times to improve the inter- and intra-expert reliability and to optimise the observation procedure. Interobserver reliability for all of the assessments was good, with a percentage of agreement between 80 and 100% (mean 97%). Of the 15 questions, seven questions, such as: 'Is your desk on the ergonomically recommended height?', were validated by direct measurements and for

the analyses and comparison with the questionnaire, results were converted to a dichoto-mous, risk or no risk, score. The other eight questions such as: 'Are your arm-supports adjustable in width?', were validated by on-site observations.

The participants of the workstation assessment were observed at their workstation while doing their normal working activities for at least 5 min. In this period, their use of the furniture and the computer workstation physical attributes was observed. After the observation, the measurements of workstation dimensions were taken. The workstation assessment was carried out using a checklist developed to assess the presence of computer workstation physical attributes (e.g. foot support), the adjustability of the furniture (e.g. arm supports) and the workstation dimensions
(e.g. desk height). (The checklist (Appendix 2) can be found at *http://www.rsiquickscan. com/research/validity/*).

Concurrent validity was tested by comparing the answers given on the RSI QuickScan with results of the original questionnaires or with results of the on-site observations and direct measurements. Also, for the concurrent validity, the percentage of agreement and Cohen's Kappa with 95% CI and the Ppositive and Pnegative were calculated.

Results

Internal consistency

Cronbach's alpha was mostly between 0.40 and 0.85, showing a varying internal consistency for the 10 scales. Six scales scored 0.70 or higher. However, the scale on work periods and the three scales on workplace ergonomics all scored between 0.30 and 0.45 (Figure 1).

Internal consistency
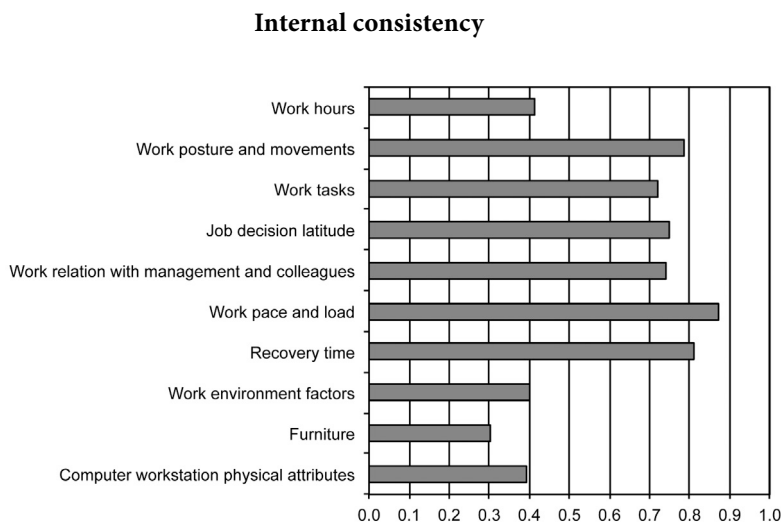
Figure 1. *Internal consistency of the RSI QuickScan, expressed in Cronbach's alpha scores, is presented for the 10 scales of the questionnaire.*

Test-retest reliability

In all, 96% of the questions scored a percentage of agreement of over 80% and 100% of the questions scored a percentage of agreement of over 70%, with a median of 90% (range 75-100%). Cohen's Kappa values were equal or higher than 0.4 for 95% of the questions, 73% of the questions scored 0.6 or more and 24% of the questions scored 0.8 or more. The Ppositive and Pnegative had medians of 90% (range 33-100%) and 88% (range 0-100%), respectively. However, there were some outliers showing low percent agreement (Figure 2a,b).

(a) Test-retest reliability
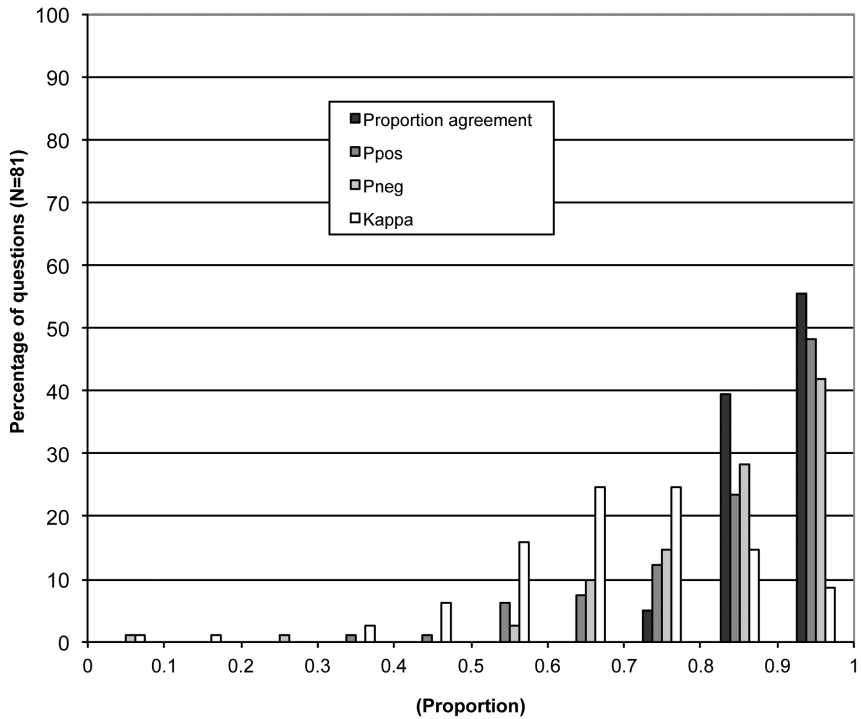
(b) Test-retest reliability
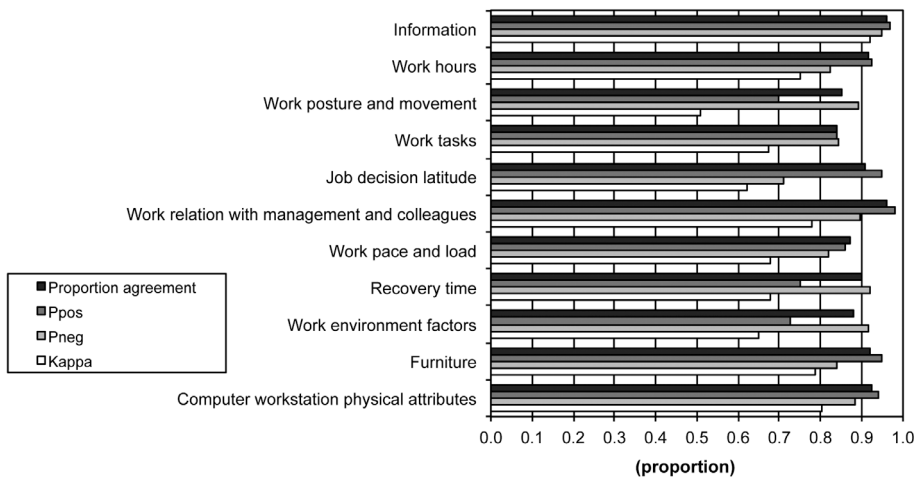
Figure 2. *Test–retest reliability of the RSI QuickScan. The histograms graphically display the propor-*
tion agreement, Ppositive, Pnegative and Cohen's Kappa. In order to be able to present all four results
in one figure, percentages (agreement, Ppositive and Pnegative) have been converted to proportions.
(a) Test–retest reliability of the RSI QuickScan for the 81 items of the questionnaire. (b) Test–retest
reliability of the RSI QuickScan for the 11 scales of the questionnaire.

Concurrent validity

Concurrent validity, except for the questions on workplace factors

In all, 66% of the questions scored a percentage of agreement of over 80%, and 100% of
the questions scored a percentage of agreement of over 70%, with a median of 83% (range
70-100%). Cohen's Kappa values were equal or higher than 0.4 for 46% of the questions,
10% of the questions scored 0.6 or more and 6% of the questions scored 0.8 or more. The
Ppositive and Pnegative had medians of 78% (range 0-100%) and 76% (range 0-100%),
respectively, with some outliers showing low percent agreement (Figure 3a,b).

(a) Concurrent validity
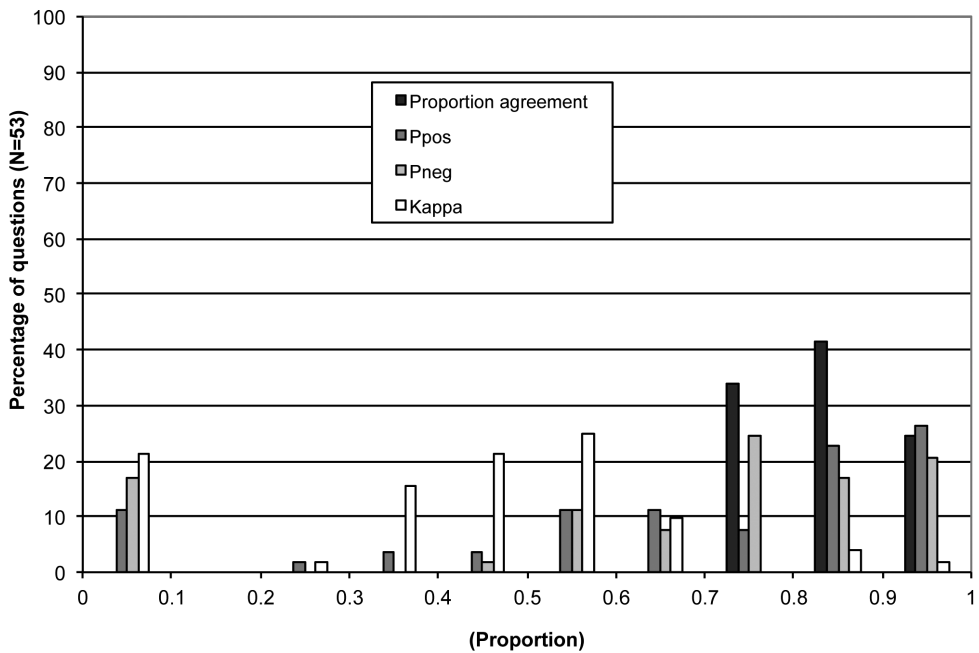
(b) Concurrent validity
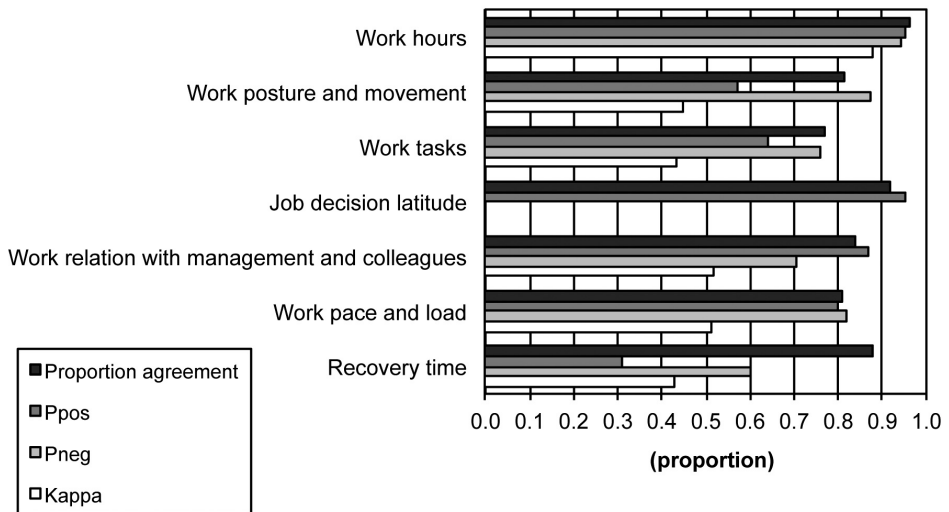
Figure 3. *Concurrent validity of the RSI QuickScan. The histograms graphically display the proportion agreement, Ppositive, Pnegative and Cohen's Kappa. In order to be able to present all four results in one figure, percentages (agreement, Ppositive and Pnegative) have been converted to proportions. (a) Concurrent validity of the RSI QuickScan for the 53 items of the questionnaire without the workplace factors. (b) Concurrent validity of the RSI QuickScan for the 7 scales of the questionnaire without the workplace factors.*

Concurrent validity of questions on workplace factors

In all, 80% of the questions scored a percentage of agreement of over 80%, and 93% of the questions scored a percentage of agreement of over 70%, with a median of 91% (range 62-98%). Cohen's Kappa values were lower than 0.4 for 80% of the questions and 20% of the questions scored 0.6 or more. The Ppositive had a median of 95% (range 0-99%), but the Pnegative had a median of only 20% (range 0-94%) (Figure 4a,b).

(a) Concurrent validity

(b) Concurrent validity
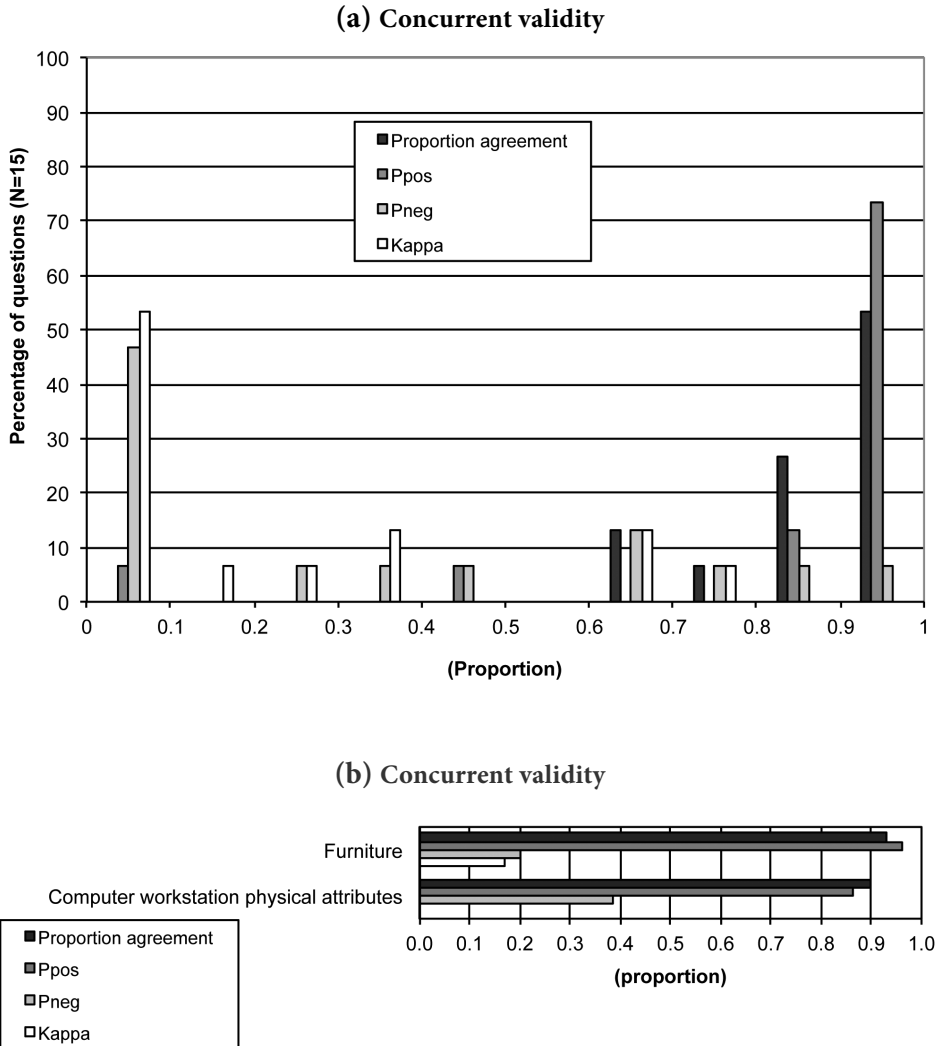
Figure 4. *Concurrent validity for the questions on workplace factors of the RSI QuickScan. The histograms graphically display the proportion agreement, Ppositive, Pnegative and Cohen's Kappa. In order to be able to present all four results in one figure, percentages (agreement, Ppositive and Pnegative) have been converted to proportions. (a) Concurrent validity of the questions on workplace factors of the RSI QuickScan for the 15 items of the questionnaire that concern the workplace factors. (b) Concurrent validity for the questions on workplace factors of the RSI QuickScan for the 2 scales of the questionnaire that concern the workplace factors.*

The results of all individual questions concerning the test-retest reliability Appendix 3) and concurrent validity (Appendix 4) of the questionnaire can be found at: *http://www.rsiquickscan.com/research/validity/*

Discussion

The aim the present study was to determine the internal consistency, test-retest reliability and concurrent validity RSI QuickScan. According to the current study, the results generally indicate that the RSI QuickScan has an acceptable internal consistency, test-retest reliability and concurrent validity.

Internal consistency

A Cronbach's alpha of at least 0.70 is suggested to indicate acceptable internal consistency, while an alpha score over 0.90 most likely indicates redundancy rather than a desirable level of internal consistency [31-33]. The internal consistency of most scales was acceptable (see results, Figure 1), except for the scale on work hours and the three scales on workplace ergonomics (work environment factors, furniture and computer workstation physical attributes). This is not surprising, since these three scales consist of questions fairly independent of each other, except the fact that they all deal with office ergonomics. In a study by Eltayeb et al. [27], the subscale on office equipment also scored an unsatisfactory Cronbach's alpha score of 0.51. For workplace factors, such as work environment factors, furniture, and computer workstation physical attributes, a Cronbach's alpha between 0.30 and 0.40 was observed. Therefore, the results of the present study indicate that workplace factors need to be analyzed separately.

Test-retest reliability

The test-retest reliability results were generally good. Test-retest reliability, was investigated by giving the participants the second questionnaire four weeks after they had received the first one. This is a longer interval than in most other studies, where the time between measurements ranged from 10 minutes to 4 weeks, with most studies using an interval between 2 days and 2 weeks [34]. On the one hand, it is important to have sufficient time between the two measurements, in order to reduce the chance of recall bias. On the other hand, the interval should not be too long, because changes might have taken place in the work environment of the participants, which could negatively bias results. Since it is well conceivable that changes may have taken place in 4 weeks, the present results are likely to be conservative. Nevertheless, the test-retest reliability appeared to be good.

Validity

The concurrent validity of the RSI QuickScan was acceptable, with a high percentage of agreement and predominately good values for both Ppositive and Pnegative.
Only the questions on workplace factors showed a poor Pnegative score. This implies that the questions on workplace factors are more suited to detect the presence of risk

factors among computer users than the absence of risk factors. For some questions with a symmetrical unequal distribution of the observations, the high level of agreement may be due to low sensitivity.

The concurrent validity of questions from five of the eleven scales in the RSI QuickScan questionnaire was tested by comparing them to the questions in the original questionnaire. It is important to note that the use of on-site expert observation and direct measurements is not practically feasible for these scales, which address work-related psychosocial factors, such as recovery time and work relation with management and colleagues. These questions (n = 34) constitute 42% the RSI QuickScan.

The validity of workplace factors was explored by on-site expert observation and direct measurements, with good interobserver reliability. There was approximately a 4-week interval between answering the questions on workplace aspects of the questionnaire and the actual workplace assessment. This is a quite long interval and leaves time for changes to take place in the workplace of the participants and may, therefore, have had a negative effect on the measures of agreement. Nevertheless, the concurrent validity appeared to be acceptable and the concurrent validity of questions on workplace factors, the percentage of agreement, appeared to be good.

The validity of self-report, e.g. estimation of duration of computer use and postural load by means of questionnaires, has been questioned [35-39]. Results from the study by Heinrich et al. (2004) showed that, on average, computer workers overestimated their total computer use by 1.6 hours (mean difference 39%). In total, 10 of the 11 items on postural load had a Cohen's Kappa score of less than 0.40 and one item scored between 0.40 and 0.60. Altman [40] defines a Kappa value less than 0.40 as poor and a Kappa value between 0.40 and 0.60 as average. The results of the present study indicate that the dichotomous characterisation of the workplace factors corresponds well to the real situation as measured by the observers. This suggests that, in contrast to the duration of computer use and postural load, workstation characteristics can be validly assessed through self-report by means of a questionnaire. IJmker and co-workers also concluded in their study that their web-based questionnaire collected reliable data on workstation characteristics [41]. Workstation characteristics, such as distance of keyboard to table edge, keyboard tilt, keyboard type, mouse type, monitor location, chair height and mouse characteristics, all had percentage of agreement values of more than 0.80 for the test-retest analysis and agreement with observations. However, it is important to note that workstation characteristics only have a partial effect on posture. The percentage agreement between questionnaire and manual goniometer measurements was much lower [41].

Strong agreement between a questionnaire and direct measurement was also found by Karlqvist et al. [42]. Results from this study showed that the test-retest analyses of the self-reported location of keyboard scored a Kappa value of 0.79 and for the direct measurements a Kappa value of 0.59. The test-retest analyses of the mouse location scored a

Kappa value of 0.81 and for the direct measurement a Kappa value of 0.68. In this study, the dichotomous characterization may have reduced the risk of misclassification. For more detailed assessment, questionnaires appear to be less suitable [24].

Indices of agreement

The indices used for assessing agreement both in the study on test-retest reliability and on validity warrant some discussion. Even though crude agreement indices are important statistics with a unique common-sense value, binary agreement between two measurements is often expressed in the Cohen's Kappa coefficient. The advantage of Kappa over 'crude' or 'raw' agreement is that it takes into account the agreement occurring by chance and subsequently corrects for this. In order to be able to compare our results to those of other studies, Kappa was calculated and presented in this study. There are, however, some known problems with the use and interpretation of Kappa. When there are only few answers in one category, as there often were in this study, Kappa can give a misrepresented picture of the validity. This is caused by the problems of two paradoxes as described by Cicchetti and Feinstein [30]. The first paradox is a high agreement (e.g. > 0.80), but low Kappa (e.g. < 0.40), caused by an unequal division of the marginal totals. In the present study, as in many other studies, this would be a problem for those questions where most answers are in one category. The second paradox arises because higher Kappa values are given at an asymmetrical unequal distribution than at a symmetrical unequal distribution. This especially plays a role at high crude agreement [30]. Also in other studies it is acknowledged that the Kappa is not suitable [30, 43-45].

Therefore, it was decided to assess the test-retest reliability and the concurrent validity of the RSI QuickScan primarily on the basis of the percentage of agreement with 95% CI. Since the percentage of agreement alone, as an omnibus index, shows no insight in the agreement between the positive and negative answers, Ppositive and Pnegative were also calculated as extra means of assessing agreement [30]. For example, Ppositive estimates the conditional probability, given that one of the raters, randomly selected, makes a positive rating, that the other rater will also do so. The joint consideration of Ppositive and Pnegative addresses the objection that with extreme prevalences or 'base rates' agreement may be high by chance alone [46].

Limitations

For the study of the internal consistency and the test-retest reliability the population consisted of 86 computer workers. The concurrent validity of the questionnaire was tested among two different groups; both groups consisted of 73 computer workers. The sample sizes were relatively small, which limits the generalisability of the results. However, the study population consisted of computer workers with diverse educational levels, ranging form intermediate to university education. The study population's age was mostly between 20 and 59 years old and even though females were slightly over-represented in the study, this population is representative for many organisations with computer workers. The questionnaire thus appears suited for use in a heterogeneous of office workers. However, it is important to note that the performance of the scale among persons of any specific demographic may not be similar to that of the entire group.

Outlook

An advantage of the RSI QuickScan is that, in comparison with the VBA, it consists of a relatively small number of questions. Respondents are able to complete the total questionnaire in an average of 15 minutes. Because the RSI QuickScan is specifically designed for and aimed at computer workers instead of the general working population, we were able to reduce the number of questions. The fact that all the answers are given online and are coded by numerical values facilitates analysis at a group level. The questionnaire was developed for use in an occupational health service. It is currently not only being used as a tool to investigate the prevalence of and risk factors for arm, shoulder and neck symptoms, but also as a means to investigate the (cost-) effectiveness of (ergonomic) interventions. Furthermore, the fact that the questionnaire is Internet based makes it possible to inform the respondents immediately of their result and to give advice. Information is given at the completion of each scale by means of a score, a column chart indicating the level on a 1 to 10 scale and written feedback, which provides the respondent with an interpretation of the score. Furthermore, the respondent gets specific advice based on the score for each scale. If the score is good the advice is to proceed as before, if the score is moderate, advice is given how to improve the situation and if the score is poor, the respondent gets advice on what he/she can do him/herself to improve the situation, but also advice to get help from professionals, such as an ergonomist or an occupational physician. After completion of the whole questionnaire, all the information (scores, charts, feedback and advice) can easily be printed by the respondent. This possibility, of an Internet-based questionnaire providing immediate feedback to the respondent, has great potential and needs to be researched further.

Conclusion

In conclusion, the results indicate that the RSI QuickScan is a measurement tool with acceptable internal consistency, reliability and concurrent validity. The questionnaire can be used as a means to rapidly collect data in a large population of office workers, in a short period of time and at low cost. To get a more accurate estimation of the duration of computer use and postural load, it is recommended to use the RSI QuickScan in combination with other assessment techniques, such as observational methods or direct measurements.

Acknowledgments

References

[1] **Houtman I, Van Hooff M, Hooftman W.** *Arbobalans 2006. Hoofddorp: TNO Kwaliteit van Leven - Arbeid; 2007.*

[2] **De Kraker H, Blatter BM.** *Prevalentiecijfers van RSI-klachten en het voorkomen van risicofactoren in 15 Europese landen. (Prevalence of RSI-complaints and the occurrence of risk factors in 15 European countries). Tijdschrift voor Gezondheidswetenschappen. 2005;83:8-15.*

[3] **Heinrich J, Blatter BM.** *RSI-klachten in de Nederlandse beroepsbevolking. Trends, risicofactoren en verklaringen. (Work-related musculoskeletal disorders of neck and upper extremity in the Dutch working population. Trends, risk factors and explanations). Tijdschrift voor Gezondheidswetenschappen. 2005;83:25-35.*

[4] **Blatter BM, Houtman I, Van den Bossche S, Kraan K, Van den Heuvel S.** *Gezondheidsschade en kosten als gevolg van RSI en psychosociale arbeidsbelasting in Nederland [Health damage and costs of RSI and psychosocial work load in the Netherlands]: Report on demand of The Dutch Ministry of Social Affairs and Employment. TNO Quality of Life; 2005.*

[5] **Van den Heuvel SG, IJmker S, Blatter BM, De Korte EM.** *Loss of productivity due to neck/shoulder symptoms and hand/arm symptoms: results from the PROMO-study. Journal of Occupational Rehabilitation. 2007;17(3):370-82.*

[6] **Marcus M, Gerr F, Monteilh C, Ortiz DJ, Gentry E, Cohen S, Edwards A, Ensor C, Kleinbaum D.** *A prospective study of computer users: II. Postural risk factors for musculoskeletal symptoms and disorders. American Journal of Industrial Medicine. 2002;41(4):236-49.*

[7] **Gerr F, Marcus M, Ensor C, Kleinbaum D, Cohen S, Edwards A, Gentry E, Ortiz DJ, Monteilh C.** *A prospective study of computer users: I. Study design and incidence of musculoskeletal symptoms and disorders. American Journal of Industrial Medicine. 2002;41(4):221-35.*

[8] **Chang CH, Amick III BC, Menendez CC, Katz JN, Johnson PW, Robertson M, Dennerlein JT.** *Daily computer usage correlated with undergraduate students' musculoskeletal symptoms. American Journal of Industrial Medicine. 2007;50(6):481-8.*

[9] **Hakala PT, Rimpela AH, Saarni LA, Salminen JJ.** *Frequent computer-related activities increase the risk of neck-shoulder and low back pain in adolescents. European Journal of Public Health. 2006;16(5):536-41.*

[10] **Juul-Kristensen B, Jensen C.** *Self-reported workplace related ergonomic conditions as prognostic factors for musculoskeletal symptoms: the "BIT" follow up study on office workers. Occupational and Environmental Medicine. 2005;62(3):188-94.*

[11] **Andersen JH, Harhoff M, Grimstrup S, Vilstrup I, Lassen CF, Brandt LPA, Kryger AI, Overgaard E, Hansen KD, Mikkelsen S.** *Computer mouse use predicts acute pain but not prolonged or chronic pain in the neck and shoulder. Occupational and Environmental Medicine. 2008;65(2):126-31.*

[12] **Brandt LP, Andersen JH, Lassen CF, Kryger A, Overgaard E, Vilstrup I, Mikkelsen S.** *Neck and shoulder symptoms and disorders among Danish computer workers. Scandinavian Journal of Work, Environment & Health. 2004;30(5):399-409.*

[13] **IJmker S, Huysmans MA, Blatter BM, Van der Beek AJ, Van Mechelen W, Bongers PM.** *Should office workers spend fewer hours at their computer? A systematic review of the literature. Occupational and Environmental Medicine. 2007;64(4):211-22.*

[14] Gerr F, Marcus M, Monteilh C. *Epidemiology of musculoskeletal disorders among computer users: lesson learned from the role of posture and keyboard use. Journal of Electromyography & Kinesiology. 2004;14:25-31.*

[15] Bongers PM, De Winter CR, Kompier MA, Hildebrandt VH. *Psychosocial factors at work and musculoskeletal disease. Scandinavian Journal of Work, Environment & Health. 1993;19(5):297-312.*

[16] Fredriksson K, Alfredsson L, Koster M, Thorbjornsson CB, Toomingas A, Torgen M, Kilbom A. *Risk factors for neck and upper limb disorders: results from 24 years of follow up [published erratum appears in Occupational and Environmental Medicine 1999;56(5):358]. Occupational and Environmental Medicine. 1999;56(1):59-66.*

[17] Viikari-Juntura E, Riihimaki H. *New avenues in research on musculoskeletal disorders. Scandinavian Journal of Work, Health & Environment. 1999;25(6):564-8.*

[18] Bongers PM, IJmker S, Van den Heuvel S, Blatter BM. *Epidemiology of work related neck and upper limb problems: Psychosocial and personal risk factors (Part I) and effective interventions from a bio behavioural perspective (Part II). Journal of Occupational Rehabilitation. 2006;16(3):272-95.*

[19] Feveile H, Jensen C, Burr H. *Risk factors for neck-shoulder and wrist-hand symptoms in a 5-year follow-up study of 3,990 employees in Denmark. International Archives of Occupational and Environmental Health. 2002;75(4):243-51.*

[20] Van Dijk FJH, Van Dormolen M, Kompier MAJ, Meijman TF. *Herwaardering model belasting-belastbaarheid. Tijdschrift voor sociale gezondheidszorg. 1990;68:3-10.*

[21] Karasek RA, Theorell T. *Healthy work: stress, productivity, and the reconstruction of working life. New York: Basis Books 1990.*

[22] Hildebrandt VH, Douwes M. *Physical load and work: questionnaire on musculoskeletal load and health complaints (In Dutch: Lichamelijke belasting en arbeid: vragenlijst bewegingsapparaat). Voorburg: Ministerie van Sociale Zaken en Werkgelegenheid, Directoraat-Generaal van de Arbeid 1991.*

[23] Hildebrandt VH, Bongers PM, Van Dijk FJH, Kemper HCG, Dul J. *Dutch Musculoskeletal Questionnaire: description and basic qualities. Ergonomics. 2001;44(12):1038-55.*

[24] Van der Beek AJ, Frings-Dresen MHW. *Assessment of mechanical exposure in ergonomic epidemiology. Occupational and Environmental Medicine. 1998;55(5):291-9.*

[25] Winkel J, Mathiassen SE. *Assessment of Physical Work Load in Epidemiologic Studies - Concepts, Issues and Operational Considerations. Ergonomics. 1994;37(6):979-88.*

[26] Dane D, Feuerstein M, Huang GD, Dimberg L, Ali D, Lincoln A. *Measurement properties of a self-report index of ergonomic exposures for use in an office work environment. Journal of Occupational & Environmental Medicine. 2002;44(1):73-81.*

[27] Eltayeb S, Staal JB, Kennes J, Lamberts PH, De Bie RA. *Prevalence of complaints of arm, neck and shoulder among computer office workers and psychometric evaluation of a risk factor questionnaire. BMC Musculoskeletal Disorders. 2007;8:68.*

[28] Stock SR, Fernandes R, Delisle A, Vezina N. *Reproducibility and validity of workers' self-reports of physical work demands. Scandinavian Journal of Work, Environment & Health. 2005;31(6):409-37.*

2

[29] **SPSS.** *Statistical package for the social sciences [SPSS 14.0]. Chicago, IL 2005.*

[30] **Cicchetti DV, Feinstein AR.** *High agreement but low kappa: II. Resolving the paradoxes. Journal of Clinical Epidemiology. 1990;43(6):551-8.*

[31] **Nunnally JC.** *Psychometric theory. New York: McGraw Hill 1967.*

[32] **Nunnally JC.** *Psychometric theory. 2nd ed. New York: McGraw-Hill 1978.*

[33] **Streiner DL.** *Starting at the Beginning: An Introduction to Coefficient Alpha and Internal Consistency. Journal of Personality Assessment. 2003;80(1):99-103.*

[34] **Marx RG, Menezes A, Horovitz L, Jones EC, Warren RF.** *A comparison of two time intervals for test-retest reliability of health status instruments. Journal of Clinical Epidemiology. 2003;56(8):730-5.*

[35] **Heinrich J, Blatter BM, Bongers PM.** *A comparison of methods for the assessment of postural load and duration of computer use. Occupational and Environmental Medicine. 2004;61(12):1027-31.*

[36] **Homan MM, Armstrong TJ.** *Evaluation of Three Methodologies for Assessing Work Activity During Computer Use. Journal of Occupational and Environmental Hygiene. 2003;64(1):48-55.*

[37] **Lassen CF, Mikkelsen S, Kryger AI, Andersen JH.** *Risk factors for persistent elbow, forearm and hand pain among computer workers. Scandinavian Journal of Work, Health & Environment. 2005;31(2):122-31.*

[38] **IJmker S, Leijssen J, Blatter BM, Van der Beek AJ, Van Mechelen W, Bongers PM.** *Test-retest reliability and validity of self-reported duration of computer use at work. Scandinavian*

Journal of Work, Environment & Health. 2008;34(2):113-9.

[39] **Richter JM, Slijper HP, Over EAB, Frens MA.** *Computer work duration and its dependence on the used pause definition. Applied Ergonomics. 2008;39(6):772-8.*

[40] **Altman DG.** *Practical Statistics for medical research. London: Chapman & Hall 1991.*

[41] **IJmker S, Mikkers J, Blatter BM, Van der Beek AJ, Van Mechelen W, Bongers PM.** *Test-retest reliability and concurrent validity of a web-based questionnaire measuring workstation and individual correlates of work postures during computer work. Applied Ergonomics. 2008;39(6):685-96.*

[42] **Karlqvist LK, Hagberg M, Koster M, Wenemark M, Nell R.** *Musculoskeletal Symptoms among Computer-assisted Design (CAD) Operators and Evaluation of a Self-assessment Questionnaire. International Journal of Occupational and Environmental Health 1996;2(3):185-94.*

[43] **Berk RA.** *Generalizability of behavioral observations: a clarification of interobserver agreement and interobserver reliability. American journal of mental deficiency. 1979;83(5):460-72.*

[44] **Maclure M, Willett WC.** *Misinterpretation and misuse of the kappa statistic. American journal of epidemiology. 1987;126(2):161-9.*

[45] **Uebersax JS.** *Diversity of Decision-Making Models and the Measurement of Interrater Agreement. Psychological Bulletin. 1987;101(1):140-6.*

[46] **Uebersax JS.** *Raw Agreement Indices. 2002 10 March 2008 [cited; Available from: http://ourworld.compuserve.com/homepages/ jsuebersax/raw.htm*

Appendix 1.

Overview of the content (main areas, scales and questions) of the Internet-based questionnaire RSI QuickScan for the assessment of risk factors.

Main areas	Scales and questions

Work

Information

1. Information on computer work and health

Work hours

2. Amount of work hours per week
3. Amount of work days per week
4. Hours computer work per day
5. Hours private computer use per day
6. Amount of breaks per day
7. Total break time per day

Work posture and movement

8. Upper body slightly bent forward
9. Upper body bent forward a lot
10. Trunk slightly twisted
11. Trunk twisted a lot
12. Upper body bent forward and twisted
13. Neck hunched forward
14. Neck hunched backward
15. Neck twisted
16. Wrist bent
17. Wrist extended
18. Wrist twisted

Work tasks

19. Repetitive movements arm. hand fingers
20. Repetitive twisting/bending upper body
21. Repetitive twisting/bending upper body
22. Same work all day
23. Same work every day
24. Repetitive movements

Job decision latitude

25. Choose time begin/stop work
26. Choose time breaks
27. Choose which days off
28. Choose how to do your work
29. Choose order of work tasks
30. Choose when work tasks
31. Leave workspace
32. Choose stop work
33. Control work pace

(continued)

Appendix 1. *(continued)*

Main areas	Scales and questions
Work	**Work relation with management and colleagues**

34. Good management
35. Irritated by others
36. Management notes what you say
37. Good general atmosphere
38. Management knows you / your work
39. Support direct supervisor
40. Support colleague
41. Sufficient information from company

Work pace and load

42. Pace of work / work load regularly high
43. Regularly work under time pressure
44. Hurry to finish on time
45. Regularly problems pace work / work load
46. Should take it easier
47. Work too tiring
48. Have to work very fast
49. A tremendous amount of work
50. Enough time to finish work

Recovery time

51. Feel mentally exhausted
52. Feel empty after a days work
53. Feel tired when waking up in the morning
54. Feel 'burned out'
55. Feel frustrated by job
56. Feel work asks too much
57. Feel at the end of your tether

Office ergonomics   **Work environment factors**

58. Bothered by light from outside
59. Bothered by reflection in your monitor
60. Cold draughts or changes in temperature
61. Disturbed by noise

Furniture

62. Correct height chair
63. Comfortable chair
64. Correct height arm rests
65.. Adjustable width arm rests
66. Correct length arm rests
67. Correct height desk
68. Adjustable height desk
69. Sufficient work surface
70. Sufficient leg room
71. Availability footrest

(continued)

Appendix 1. *(continued)*

Main areas	Scales and questions
Office ergonomics	**Computer workstation physical attributes**

72. Availability external mouse and keyboard
73. Hindered by length mouse cable
74. Mouse works properly
75. Document holder available
76. Head set
77. Correct height monitor
78. Correct viewing distance monitor
79. Eyesight test
80. Need for computer glasses
81. Disposal of computer glasses

2

Appendix 2.

Checklist expert observation and direct measurements.

dna = does not apply

No.	Questions derived from the RSI QuickScan	Risk score 0=no risk 1=risk	Expert observation (EO) or direct measurement (DM	Definitions
66	Does your chair have the correct height? (feet on the floor and without much pressure from the seat on the front dorsal side of the thigh)?	Yes = 0 No = 1	- Observe and check the position of the feet and whether there is much pressure from the seat on the front dorsal side of the thigh.	Yes = Feet on the floor and no pressure from the seat under the front dorsal side of the thigh. No = Feet not on the floor and no pressure from the seat under the front dorsal side of the thigh.
68	Are your arms supported at elbow height (when you are sitting with relaxed shoulders)?	Yes = 0 No = 1 dna = 0	- Measure the space between the elbow and the floor (when the shoulders are relaxed) and the height of the arm support.	Yes = the space between the elbow and the floor (when the shoulders are relaxed) and the height of the arm support is between 1-3 cm No = the space between the elbow and the floor (when the shoulders are relaxed) and the height of the arm support is between greater than 3 cm dna = absence of arm support.
69	Are your arm supports adjustable in width?	Yes = 0 No = 1 dna = 0	- Check whether it is possible to adjust the width of the arm support.	Yes = it is possible to adjust the width of the arm support. No = it is not possible to adjust the width of the arm support. dna = absence of arm support.
70	Do your arm supports keep you from sitting close to your desk?	Yes = 1 No = 0 dna = 0	- Observe whether the worker has a forward bent position of the upper body. - Measure the smallest possible distance between the belly and desk.	Yes = the worker has a forward bent position of the upper body or the smallest possible distance between the belly and desk is larger than 5 cm. No = the worker does not have a forward bent position of the upper body and the smallest possible distance between the belly and desk is smaller than 5 cm. dna = absence of arm support.

(continued)

Appendix 2. *(continued)*

No.	Questions derived from the RSI QuickScan	Risk score 0=no risk 1=risk	Expert observation (EO) or direct measurement (DM	Definitions
71	Is your desk on the correct (elbow height) height?	Yes = 0 No = 1	- Measure the height of the desk. - Measure the space between the elbow and the floor (when the shoulders are relaxed).	Yes = when the difference between the height of the desk and the elbow not larger than +/- 3 cm. No = when the difference between the height of the desk and the elbow larger than +/- 3 cm.
72	Is your desk adjustable in height?	Yes = 0 No = 1	- Check whether it is possible to adjust the height of the desk.	Yes = it is possible to adjust the height of the desk. No = it is not possible to adjust the height of the desk.
73	Is your desk large enough for your tasks?	Yes = 0 No = 1	- Measure the width and depth of the desk.	Yes = the width of the desk ≥ 120 cm and depth of the desk ≥ 80 cm. No = the width of the desk < 120 cm and depth of the desk < 80 cm.
74	Is there enough leg space under your desk? (At least 70 cm x 60 cm)?	Yes = 0 No = 1	- Measure the width and depth of the leg space under your desk.	Yes = the width ≥ 60 cm and the depth ≥ 70 cm. No = the width < 60 cm and the depth < 70 cm.
75	Do you have a foot support, if your desk is too high?	Yes = 0 No = 1 dna = 0	- Check whether a foot support available.('dna' if desk is not to high).	Yes = a foot support available. No = a foot support is not available. dna = the desk height is correct; no need for a footrest.
76	If you work with a laptop for two hours a day or more, do you use an external mouse and keyboard?	Yes = 0 No = 1 dna = 0	- Observe whether the worker uses a laptop for two hours a day or more. - Observe whether the worker uses an external mouse and keyboard.	Yes = the worker uses an external mouse and keyboard. No = the worker does not use an external mouse and keyboard. dna = the worker does not use a for two hours a day or more.
77	Is the length of your mouse cable limiting you while using the mouse?	No = 0 Yes = 1	- Check whether the mouse reaches the desk edge left and right of your keyboard.	Yes = the mouse does not reach the desk edge left and right of your keyboard. No = the mouse reaches the desk edge left and right of your keyboard.

(continued)

Appendix 2. *(continued)*

No.	Questions derived from the RSI QuickScan	Risk score 0=no risk 1=risk	Expert observation (EO) or direct measurement (DM	Definitions
79	Do you use a suitable document holder for typing over data?	Yes = 0 No = 1 dna = 0	- Observe whether the worker enters data from paper to the computer. - Observe whether a document holder is available.	Yes = the worker enters data from paper to the computer and a document holder is available. No = the worker enters data from paper to the computer and a document holder is not available. dna = the worker doe not enter data from paper to the computer.
80	Do you use a headset when telephoning and working with the computer at the same time?	Yes = 0 No = 1 dna = 0	- Observe whether a headset is available and whether the worker uses a headset when telephoning and working with the computer at the same time	Yes = a headset is available and the worker uses a headset when telephoning and working with the computer at the same time No = a headset is not available or the worker does not use a headset when telephoning and working with the computer at the same time dna = the worker does not use the telephone whilst working with the computer.
81	Is your monitor on the correct height? (Viewing angle 0-35°, thus between eye- en desk height)?	Yes = 0 No = 1	- Measure the distance between the desk surface and the eyes of the worker. - Measure the distance between the desk surface and the top from the computer screen.	Yes = the distance between the desk surface and the eyes of the worker is greater or equal to the distance between the desk surface and the top from the computer screen. No = the distance between the desk surface and the eyes of the worker is smaller than the distance between the desk surface and the top from the computer screen.
82	Is your monitor on the correct distance? 15 inch: 55-75 cm, 17 inch: 60-85 cm, 19 inch: 70-95 cm and 21 inch: 75-105	Yes = 0 No = 1	- Measure the computer screen in inches. - Measure the distance between the eyes of the worker and the computer screen in cm.	Yes = the distance between the eyes of the worker and the computer screen is between 55-75 cm for a 15 inch screen; between 60-85 cm for a 17 inch screen; between 70-95 cm for a 19 inch screen and between 75-105 cm for a 21 inch screen. No = the distance between the eyes of the worker and the computer screen is smaller or greater as specified above.

Appendix 3.

Test-retest reliability scores of the individual questions.

nr.	Question	PO	(ll - ul)	Ppos	Pneg	Kappa	(ll – ul)
	Information						
5	Information on computer work and health	96%	(91 – 100)	97	95	0.92	(0.81 - 1.03)
	Work hours						
6	Amount of work hours per week	94%	(88 – 100)	93	96	0.88	(0.75 - 1.01)
7	Amount of work days per week	100%	(100 – 100)	100	100	1	(1.00 - 1.00)
8	Hours computer work per day	89%	(80 – 97)	92	72	0.65	(0.43 - 0.86)
9	Hours private computer use per day	94%	(88 – 100)	97	77	0.74	(0.45 - 1.03)
10	Amount of breaks per day	88%	(79 – 97)	89	87	0.77	(0.59 - 0.94)
11	Total break time per day	79%	(68 – 90)	79	78	0.58	(0.36 - 0.80)
	Work posture and movement						
12	Upper body slightly bent forward	85%	(75 – 95)	89	78	0.66	(0.45 - 0.88)
13	Upper body bent forward a lot	96%	(90 – 100)	50	98	0.48	(-0.22 - 1.18)
14	Trunk slightly twisted	92%	(84 – 100)	88	94	0.82	(0.64 - 0.99)
15	Trunk twisted a lot	94%	(87 – 100)	40	97	0.37	(-0.33 - 1.06)
16	Upper body bent forward and twisted	88%	(79 – 97)	70	92	0.62	(0.34 - 0.91)
17	Neck hunched forward	75%	(63 – 87)	78	70	0.48	(0.24 - 0.73)
18	Neck hunched backward	96%	(90 – 100)	50	98	0.48	(-0.23 - 1.19)
19	Neck twisted	82%	(71 – 93)	73	86	0.59	(0.35 - 0.83)
20	Wrist bent	79%	(68 – 90)	65	85	0.51	(0.26 - 0.77)
21	Wrist extended	81%	(70 – 92)	71	86	0.57	(0.33 - 0.81)
22	Wrist twisted	82%	(72 – 93)	61	89	0.50	(0.20 - 0.80)
	Work tasks						
23	Repetitive movements arm, hand, fingers	89%	(80 – 97)	92	80	0.72	(0.51 - 0.93)
24	Repetitive twisting/bending upper body	83%	(72 - 93)	69	88	0.57	(0.31 - 0.83)
25	Repetitive twisting/bending upper body	81%	(70 - 92)	82	80	0.62	(0.40 - 0.83)
26	Same work all day	84%	(74 - 94)	86	82	0.68	(0.48 - 0.88)
27	Same work every day	88%	(79 - 97)	86	90	0.76	(-0.19 - 1.68)
28	Repetitive movements	84%	(74 - 94)	80	87	0.67	(1.17 - 0.42)
	Job decision latitude						
29	Choose time begin/stop work	89%	(80 - 97)	90	88	0.77	(0.60 - 0.94)
30	Choose time breaks	94%	(88 - 100)	96	91	0.87	(-0.37 - 1.98)
31	Choose which days off	87%	(78 - 96)	93	22	0.17	(-0.40 - 0.74)
32	Choose how to do your work	85%	(75 - 95)	90	71	0.61	(0.36 - 0.86)
33	Choose order of work tasks	94%	(88 - 100)	97	57	0.54	(0.04 - 1.05)
34	Choose when work tasks	91%	(83 - 98)	95	67	0.62	(0.30 - 0.94)
35	Leave workspace	94%	(88 - 100)	96	73	0.70	(0.36 - 1.03)
36	Choose stop work	93%	(85 – 100)	96	60	0.56	(0.15 - 0.98)
37	Control work pace	91%	(83 - 98)	94	74	0.68	(0.42 - 0.95)

(continued)

Appendix 3. *(continued)*

nr.	Question	PO	(ll - ul)	Ppos	Pneg	Kappa	(ll – ul)
	Work relation with management and colleagues						
38	Good management	96%	(90 - 100)	98	89	0.86	(0.68 - 1.05)
39	Irritated by others	87%	(78 - 96)	59	92	0.51	(0.17 - 0.85)
40	Management notes what you say	98%	(94 - 100)	99	95	0.94	(0.81 - 1.06)
41	Good general atmosphere	100%	(100 - 100)	100	100	1	(1.00 - 1.00)
42	Management knows you / your work	90%	(82 - 98)	94	76	0.70	(0.45 - 0.95)
43	Support direct supervisor	96%	(91 - 100)	98	90	0.87	(0.71 - 1.04)
44	Support colleague	98%	(95 - 100)	99	67	0.66	(-0.01 - 1.32)
45	Sufficient information from company	87%	(78 - 96)	90	80	0.70	(0.50-0.91)
	Work pace and load						
46	Pace of work / work load regularly high	86%	(77 - 96)	90	76	0.66	(0.43 - 0.90)
47	Regularly work under time pressure	87%	(77 - 96)	89	82	0.71	(0.52 - 0.91)
48	Hurry to finish on time	77%	(66 - 88)	68	82	0.50	(0.26 - 0.75)
49	Regularly problems pace work / work load	89%	(80 - 97)	75	93	0.68	(0.44 - 0.92)
50	Should take it easier	90%	(82 - 98)	84	93	0.76	(0.58 - 0.96)
51	Work too tiring	94%	(87 - 100)	86	96	0.82	(0.62 - 1.02)
52	Have to work very fast	92%	(85 - 100)	90	94	0.84	(0.68 - 0.99)
53	A tremendous amount of work	83%	(72 - 93)	85	79	0.65	(0.44 - 0.86)
54	Enough time to finish work	85%	(75 - 94)	87	81	0.68	(0.48 - 0.88)
	Recovery time						
55	Feel mentally exhausted	87%	(77 - 96)	59	92	0.51	(0.17 - 0.85)
56	Feel empty after a days work	90%	(82 - 98)	86	92	0.79	(0.61 - 0.96)
57	Feel tired when waking up in the morning	85%	(75 - 94)	50	91	0.42	(0.04 - 0.79)
58	Feel 'burned out'	96%	(91 - 100)	75	98	0.73	(0.37 - 1.10)
59	Feel frustrated by job	93%	(85 - 100)	33	96	0.30	(-0.36 - 0.96)
60	Feel work asks too much	87%	(77 - 96)	77	90	0.68	(0.46 - 0.90)
61	Feel at the end of your tether	96%	(91 - 100)	75	98	0.73	(0.36 - 1.10)
	Work environment factors						
62	Bothered by light from outside	91%	(83 - 98)	62	95	0.56	(0.20 - 0.93)
63	Bothered by reflection in your monitor	94%	(88 - 100)	67	97	0.64	(0.24 - 1.04)
64	Cold, draughts or changes in temperature	85%	(75 - 95)	84	86	0.70	(0.50 - 0.89)
65	Disturbed by noise	85%	(75 - 94)	78	88	0.66	(0.45 - 0.88)
	Furniture						
66	Correct height chair	92%	(85 - 100)	96	67	0.63	(0.27 - 0.98)
67	Comfortable chair	94%	(88 - 100)	97	73	0.70	(0.36 - 1.03)
68	Correct height arm rests	92%	(85 - 100)	95	83	0.79	(0.58 - 0.99)
69	Adjustable width arm rests	94%	(88 - 100)	94	91	0.84	(0.71 - 0.98)
70	Correct length arm rests	90%	(82 - 98)	86	93	0.79	(0.61 - 0.96)

(continued)

Appendix 3. *(continued)*

nr.	Question	PO	(ll - ul)	Ppos	Pneg	Kappa	(ll – ul)
71	Correct height desk	92%	(85 - 100)	95	78	0.73	(0.48 - 0.98)
72	Adjustable height desk	90%	(82 - 98)	90	91	0.81	(0.65 - 0.97)
73	Sufficient work surface	90%	(82 - 98)	93	85	0.78	(0.59 - 0.96)
74	Sufficient leg room	98%	(94 - 100)	99	0	0.00	(-2.02 - 2.02)
75	Availability footrest	96%	(91 - 100)	98	88	0.85	(0.65 - 1.05)
	Computer workstation physical attributes						
76	Availability external mouse and keyboard	90%	(82 - 98)	95	55	0.49	(0.07 - 0.91)
77	Hindered by length mouse cable	96%	(90 - 100)	88	98	0.85	(0.78 - 0.93)
78	Mouse works properly	89%	(75 - 100)	91	85	0.76	(-1.73 - 3.24)
79	Document holder available	95%	(83 - 100)	96	93	0.89	(0.71 - 1.06)
80	Head set	97%	(89 - 100)	94	98	0.92	(0.79 - 1.04)
81	Correct height monitor	90%	(67 - 100)	94	67	0.61	(0.67 - 1.12)
82	Correct viewing distance monitor	88%	(67 - 100)	92	67	0.59	(0.67 - 1.08)
83	Eyesight test	87%	(68 - 100)	92	70	0.61	(0.41 - 0.82)
84	Need for computer glasses	96%	(86 - 100)	98	92	0.90	(0.85 - 0.95)
85	Disposal of computer glasses	100%	(100 - 100)	100	100	1.00	(1.00 - 1.00)

2

Appendix 4.

Concurrent validity scores of the individual questions.

Grey highlighted scores were validated through a workplace assessment

nc= not calculated, because one of the variables is a constant

nr.	Question	PO	(ll - ul)	Ppos	Pneg	Kappa	(ll – ul)
	Information						
5	Information on computer work and health						
	Work hours						
6	Amount of work hours per week	96%	(89 - 100)	91	97	0.88	(0.78 - 0.98)
7	Amount of work days per week	100%	(100 - 100)	100	100	1.00	(1.00 - 1.00)
8	Hours computer work per day						
9	Hours private computer use per day						
10	Amount of breaks per day	89%	(67 - 100)	93	62	0.55	(0.38 - 0.73)
11	Total break time per day	96%	(84 - 100)	97	91	0.88	(0.79 - 0.97)
	Work posture and movement						
12	Upper body slightly bent forward	81%	(64 - 97)	82	79	0.61	(-0.73 - 1.96)
13	Upper body bent forward a lot	89%	(80 - 98)	0	94	-0.06	(-0.15 - 0.04)
14	Trunk slightly twisted	82%	(70 - 95)	56	89	0.45	(0.29 - 0.60)
15	Trunk twisted a lot	96%	(90 - 100)	0	98	0.00	(-0.06 - 0.06)
16	Upper body bent forward and twisted	93%	(86 - 100)	57	96	0.54	(0.45 - 0.62)
17	Neck hunched forward	74%	(56 - 92)	77	70	0.48	(0.02 - 0.94)
18	Neck hunched backward	95%	(88 - 100)	0	98	0.00	(-0.07 - 0.07)
19	Neck twisted	79%	(65 - 93)	57	86	0.44	(0.22 - 0.66)
20	Wrist bent	77%	(63 - 91)	67	83	0.49	(0.27 - 0.72)
21	Wrist extended						
22	Wrist twisted	75%	(59 - 91)	63	81	0.45	(0.07 - 0.83)
	Work tasks						
23	Repetitive movements arm. Hand fingers	77%	(58 - 96)	78	76	0.55	(0.03 - 1.07)
24	Repetitive twisting/bending upper body	77%	(64 - 90)	42	86	0.28	(0.13 - 0.44)
25	Repetitive twisting/bending upper body	75%	(60 - 89)	54	82	0.36	(0.16 - 0.56)
26	Same work all day	75%	(59 - 91)	74	76	0.51	(0.20 - 0.82)
27	Same work every day	77%	(57 - 97)	81	70	0.52	(0.01 - 1.02)
28	Repetitive movements	81%	(69 - 93)	21	50	0.36	(0.21 - 0.50)
	Job decision latitude						
29	Choose time begin/stop work	79%	(57 - 100)	87	50	0.38	(-5.84 - 6.60)
30	Choose time breaks	94%	(60 - 100)	97	0	-0.03	(-0.36 - 0.31)
31	Choose which days off	92%	(67 - 100)	95	60	0.55	(0.49 - 0.61)
32	Choose how you do your work	81%	(43 - 100)	90	0	-0.10	(-0.48 - 0.28)
33	Choose order of work tasks	96%	(nc - nc)	98	0	0.00	(nc – nc)
34	Choose when work tasks	90%	(63 - 100)	94	44	0.39	(0.28 - 0.50)
35	Leave workspace	96%	(57 - 100)	98	0	-0.02	(-0.41 - 0.37)
36	Choose stop work	100%	(nc - nc)	100	0	nc	(nc - nc)
37	Control work pace	85%	(55 - 100)	92	0	-0.06	(-0.37 - 0.25)

(continued)

Appendix 4. *(continued)*

Grey highlighted scores were validated through a workplace assessment
nc= not calculated, because one of the variables is a constant

nr.	Question	PO	(ll - ul)	Ppos	Pneg	Kappa	(ll – ul)
	Work relation with management and colleagues						
38	Good management	76%	(58 - 94)	78	73	0.52	(-0.70 - 1.74)
39	Irritated by others	85%	(74 - 96)	46	91	0.37	(0.24 - 0.50)
40	Management notes what you say	87%	(63 - 100)	92	63	0.54	(0.42 - 0.67)
41	Good general atmosphere	94%	(60 - 100)	97	0	-0.03	(-0.37 - 0.31)
42	Management knows you / your work	82%	(63 - 100)	87	71	0.59	(0.01 - 1.17)
43	Support direct supervisor	83%	(62 - 100)	87	77	0.65	(0.49 - 0.81)
44	Support colleague	89%	(65 - 100)	94	55	0.49	(0.38 - 0.59)
45	Sufficient information from company	77%	(57 - 96)	81	70	0.51	(-0.69 - 1.71)
	Work pace and load						
46	Pace of work / work load regularly high	72%	(46 - 99)	80	55	0.37	(0.18 - 0.56)
47	Regularly work under time pressure	77%	(57 - 97)	83	67	0.49	(-0.62 - 1.60)
48	Hurry to finish on time	81%	(66 - 97)	80	82	0.63	(-0.62 - 1.87)
49	Regularly problems with of work pace/load	89%	(80 - 99)	55	94	0.49	(0.38 - 0.60)
50	Should take it easier	79%	(65 - 94)	64	85	0.51	(0.21 - 0.80)
51	Work too tiring	92%	(83 - 100)	67	95	0.62	(0.52 - 0.72)
52	Have to work very fast	72%	(57 - 88)	61	79	0.39	(0.13 - 0.66)
53	A tremendous amount of work	83%	(67 - 99)	83	83	0.67	(-0.23 - 1.56)
54	Enough time to finish work	81%	(62 - 100)	86	73	0.59	(0.20 - 0.97)
	Recovery time						
55	Feel mentally exhausted	90%	(80 - 99)	62	94	0.56	(0.44 - 0.67)
56	Feel empty after a days work	70%	(54 - 87)	53	78	0.32	(0.01 - 0.63)
57	Feel tired when waking up in the morning	83%	(71 - 95)	31	60	0.45	(0.31 - 0.60)
58	Feel 'burned out'	88%	(78 - 97)	0	4	-0.06	(-0.16 - 0.04)
59	Feel frustrated by job	88%	(78 - 97)	32	54	0.43	(0.32 - 0.54)
60	Feel work asks too much	72%	(56 - 89)	9	77	0.43	(0.09 - 0.77)
61	Feel at the end of your tether	90%	(81 - 98)	0	9	0.00	(-0.09 - 0.09)
	Work environment factors						
62	Bothered by light from outside						
63	Bothered by reflection in your monitor						
64	Cold, draughts or changes in temperature						
65	Disturbed by noise						
	Furniture						
66	Correct height chair	93%	(85 - 100)	96	0	-0.04	(-1.02 - 0.94)
67	Comfortable chair						
68	Correct height arm rests	93%	(86 - 100)	96	0	-0.03	(-1.00 - 0.94)
69	Adjustable width arm rests	83%	(73 - 93)	90	31	0.21	(-0.26 - 0.68)
70	Correct length arm rests	81%	(71 - 92)	38	89	0.30	(-0.10 - 0.69)
71	Correct height desk	79%	(68 - 90)	87	42	0.31	(-0.06 - 0.67)
72	Adjustable height desk	85%	(75 - 95)	92	20	0.17	(-0.36 - 0.70)
73	Sufficient work surface	94%	(88 - 100)	97	0	0.00	(-1.10 - 1.10)
74	Sufficient leg room	98%	(95 - 100)	99	0	0.00	(-1.94 - 1.94)
75	Availability footrest	94%	(88 - 100)	97	67	0.64	(0.24 - 1.04)

(continued)

Appendix 4. *(continued)*

Grey highlighted scores were validated through a workplace assessment
nc= not calculated, because one of the variables is a constant

nr.	Question	PO	(ll - ul)	Ppos	Pneg	Kappa	(ll – ul)
	Computer workstation physical attributes						
76	Availability external mouse and keyboard	92%	(85 - 100)	96	0	-0.03	(-1.00 - 0.94)
77	Hindered by length mouse cable	89%	(75 - 75)	0	94	0.00	(-0.75 - 0.75)
78	Mouse works properly						
79	Document holder	91%	(83 - 98)	95	67	0.61	(0.29 - 0.94)
80	Head set	93%	(48 - 99)	96	78	0.73	(0.48 - 0.98)
81	Correct height monitor	62%	(49 - 75)	76	9	-0.13	(-0.51 - 0.26)
82	Correct viewing distance monitor	64%	(51 - 77)	78	10	-0.10	(-0.49 - 0.30)
83	Eyesight test						
84	Need for computer glasses						
85	Disposal of computer glasses						

Concurrent validity of questions on arm, shoulder and neck symptoms of the RSI QuickScan

Abstract

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Introduction: The objective was to determine the concurrent validity of questions on arm, shoulder and neck symptoms of an internet-based questionnaire. In addition, the inter-observer reliability of physical examinations by occupational physicians was investigated.

Methods: 160 employees of a Dutch occupational health service were approached of which 106 participated. Just after the assessment of arm, shoulder and neck symptoms using a self-administered questionnaire, each participant was examined by two occupational physicians. The presence of symptoms in the past 7 days was compared to the physical examinations. Because two occupational physicians participated also the inter-observer reliability was studied.

Results: Overall, the concurrent validity of the symptom questions of the questionnaire can be defined as poor to moderate with κ values between 0.16 and 0.53. Detecting the presence of symptoms (p_{pos}) could be considered as moderately valid with values below 0.60, but the p_{neg} shows that the concurrent validity for detecting the absence of arm, shoulder or neck symptoms can be considered sufficient with values above 0.69. The agreement between occupational physicians can, with a few exceptions, be considered as moderate with κ values below 0.60. The agreement was sufficient for detecting the absence of symptoms ($p_{neg} > 0.7$).

Conclusions: The agreement between the symptom questions of the questionnaire and physical examinations of occupational physicians can be considered as poor to moderate. The results are comparable to what is generally reported in literature. However, additional analyses of the inter-observed reliability of occupational physicians show that the validity of physical examinations could be questionable in populations of active computer workers.

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Introduction

A large number of people use a computer at work daily. This number as well as the number of hours per day working with a computer has increased over the years [1-3]. Computer work has been recognized as a potential risk factor for arm, shoulder and neck symptoms [2-7]. Although the scientific evidence for a causal relationship is still controversial [8, 9], in practice many computer workers visit their occupational physician in the Netherlands because of these symptoms. It is estimated that 2.5 percent of the computer workers in the Netherlands, which is 2 percent of the total working population, contact their occupational physician for arm, shoulder or neck symptoms [10-12].

Arm, shoulder and neck symptoms of workers are costly in terms of lost production, staff sickness, compensation and insurance costs, recruiting and training of new staff and the effect of discomfort or poor health on the quality of work. In the Netherlands, the total yearly costs of arm, shoulder and neck symptoms due to decreased productivity, sick leave, chronic disability and medical costs have been estimated to be 2.1 billion Euros [13]. To reduce these costs, employers monitor the prevalence of arm, shoulder and neck symptoms and potential risk factors for arm, shoulder and neck symptoms among their employees. In the Netherlands, 75% of organizations with 500 or more employees implement specific interventions aimed at reducing the exposure to the potential risk factors. Recently, an internet-based questionnaire (RSI QuickScan) was developed by an occupational health service in the Netherlands to assess the prevalence of potential risk factors and arm, shoulder or neck symptoms [14, 15]. The internal consistency, reliability and concurrent validity of questions on work-related exposure were found to be acceptable [15]. The concurrent validity was tested by comparing the results from the questions of the RSI QuickScan with direct measurements, on-site expert observations and with results from the original questionnaires that the RSI QuickScan was based on.

The symptom related questions of the RSI QuickScan still need to be validated by comparing outcomes with physical examinations by occupational physicians [16-25], usually recognized as more objective than questionnaires [26]. Therefore, the main objective of the present study was to determine the concurrent validity of the symptom related questions of the RSI QuickScan by assessing the agreement between the results of these self-administered questions and the physical examination by occupational physicians on the presence of arm, shoulder or neck symptoms in computer workers with and without arm, shoulder or neck symptoms.

In the present study, the results of the self-administered questions were compared to the physical examinations of two occupational physicians. In the course of the analyses it was noticed that the inter-observer agreement between the two occupational physicians was not optimal. Therefore, an additional objective of the present study was to explore

the inter-observer reliability of the physical examinations of the occupational physicians when applying a standardized physical examination for arm, shoulder or neck symptoms.

Methods

Study population

The research questions of the present study were addressed using two separate investigations.

Study 1

Study 1 was part of a large longitudinal study in which 2000 employees of a Dutch occupational health service (Arbo Unie) were invited in 2005 to fill in an internet-based questionnaire, the RSI QuickScan [15]. Using the total symptom score for arm, shoulder and neck symptoms that was assessed using the questionnaire, the responding employees were divided into three groups: 1) no symptoms, 2) moderate symptoms, 3) severe symptoms. For practical reasons only employees who worked in four locations of the occupational health service in major cities in the Netherlands (Amsterdam, Haarlem, The Hague and Rotterdam) and who responded to the questionnaire were approached. A representative and random sample (n=160), including employees from each of the symptom groups, was approached to participate in the present study. In total 106 (66%) employees (19 men with a mean age of 46 (SD 9) years and 87 women with a mean age of 38 (SD 10) years) decided to participate, including 64 participants with no symptoms, 32 participants with moderate symptoms and 10 participants with severe symptoms.

Study 2

Study 2, an additional study, was designed in which 11 employees (6 men with a mean age of 46 (SD 7) years and 5 women with a mean age of 50 (SD 8) years) from different companies participated who contacted (between March 2006 and August 2006) the occupational health service because of arm, shoulder or neck symptoms. The employees were on sick leave between one day and three weeks because of arm, shoulder or neck symptoms.

The Ethics Committee of the Faculty of Human Movements Sciences of the VU University Amsterdam approved the study design, protocols, procedures and informed consent form.

Procedure Study 1

Each of the 106 employees, who decided to participate in study 1 was invited to see two occupational physicians of the occupational health service. Prior to this study, both occupational physicians were trained in the procedures of physical examination concerning arm, shoulder and neck symptoms. Just before seeing the first occupational physician the participants signed the informed consent and filled in the fourteen symptom questions of the RSI QuickScan again. The occupational physicians were neither allowed to see or

hear the answers to the questions before their physical examination, nor to discuss the participant with each other before returning the forms of the study to the researchers. After filling in the questionnaire the participant was physically examined successively by both occupational physicians in separate rooms and according to the guideline on arm, shoulder or neck symptoms of the Netherlands Society of Occupational Medicine [27].

Procedure Study 2

For study 2, employees who contacted their occupational health service because of arm, shoulder or neck symptoms were also invited to see their occupational physician. Directly after the first examination, a second occupational physician was called in, to re-examine the participant. The procedure was identical to the procedure described above except that a group of in total 15 occupational physicians was involved in study 2.

Questionnaire

The RSI QuickScan was developed to assess the presence or absence of arm, shoulder or neck symptoms and potential risk factors for these symptoms for the establishment of risk profiles related to arm, shoulder and neck symptoms in computer workers [15]. The prevalence of arm, shoulder and neck symptoms was assessed using a slightly altered version of the Nordic Questionnaire published by Kuorinka et al. [28]. It specifies seven areas in the upper extremity region (neck, upper back, shoulder, elbow, forearm, wrist, hand), as suggested by Sluiter et al. [29]. The participants were asked whether they had experienced symptoms in these regions in the past twelve months and in the past seven days separately using a four-point scale (never, once or twice, regular, long-lasting; 0-3 points). The total symptom score consisted of the sum of points scored on the 14 questions (7 regions in the past 12 months and 7 days, range 0-42 points). For the comparison of the results of the self-administered questions with the physical examinations of the occupational physicians, the participants were classified as with arm, shoulder or neck symptoms using the questionnaire when they reported regular or long-lasting symptoms in one or more of the seven regions.

Physical examination

Each participant was physically examined twice according to the practice guideline for occupational physicians on the management of employees with complaints of arm, shoulder or neck of the Netherlands Society of Occupational Medicine [27]. The guideline is based on information from relevant systematic reviews, original studies and the Saltsa report on guidelines to determine upper extremity symptoms [29]. Results of the physical examination were reported using a form in which the absence or presence of specific and non-specific symptoms for four regions (neck, shoulder, elbow, forearm/wrist/hand) could be indicated. For each specific and non-specific symptom it was

determined whether the diagnosis was negative or positive. With respect to the specific symptoms the occupational physicians had the following options: cervical radicular syndrome, specific shoulder symptoms, lateral and medial epicondylitis, tenosynovitis/ peritendinitis or carpal tunnel syndrome.

Statistical analyses

Study 1

Firstly, it was descriptively explored whether prevalences of symptoms reported by the participants themselves on the RSI QuickScan questionnaire (separating symptoms in the past 7 days and past 12 months) were comparable to the results of the physical examinations of the occupational physicians (in terms of positive or negative). For these descriptions specific and non-specific symptoms were not distinguished.

Secondly, the scores of the participants on questions concerning the presence of symptoms in the past 7 days were compared to the observations of the two occupational physicians (in terms of positive or negative). Concurrent validity was determined irrespective of body region (total) and for the neck, shoulder, elbow and forearm/wrist/hand regions separately. The proportion of observed agreement (p_o) and Cohen's Kappa (κ) were calculated as measures of concurrent validity. Since p_o and show no insight into the agreement between the positive and negative answers and because the statistic is considered unstable as it is strongly influenced by the observed proportions of individuals who fall in each category of classification [15, 21, 25, 26, 30], $p_{positive}$ (p_{pos}) and $p_{negative}$ (p_{neg}) were also calculated as extra means of assessing the agreement [15, 31]. According to Cicchetti and Feinstein [31], the observed proportion of positive agreement (p_{pos}) can be calculated as the ratio of the actual number of subjects that the questionnaire and the occupational physician agree on having symptoms over the average number of subjects with symptoms that was identified by the questionnaire and the occupational physician ((cases$_{questionnaire}$ + cases$_{occupational\ physician}$)/2). Cicchetti and Feinstein [31] state that since this average value shows how many decisions were made, a correction for chance agreement seems less necessary than for the proportion of observed agreement. Analogous to the proportion of positive agreement, the proportion of negative agreement (p_{neg}) can be calculated for the subjects identified as being without symptoms.

In addition to the concurrent validity, the inter-observer reliability was studied by comparing the results of the two occupational physicians. For the inter-observer reliability again the p_o, κ, p_{pos} and p_{neg} were calculated for each of the four body regions, i.e. neck, shoulder, elbow and forearm/wrist/hand, separately for non-specific and specific symptoms.

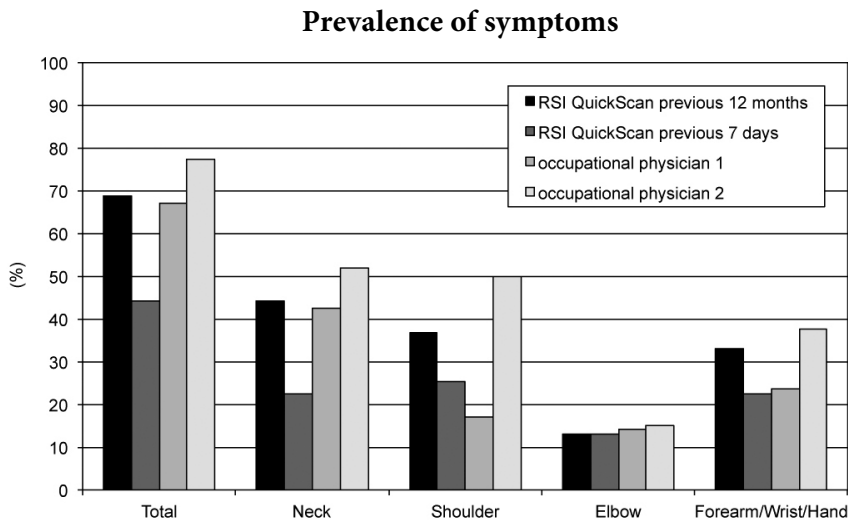## *Study 2*

To verify the generalizability of the findings of study 1, in which only two occupational physicians were involved, the inter-observer reliability of the physical examinations was also determined for the study population of study 2 for different pairs of occupational physicians out of a group of 15 occupational physicians and analyzed as described above.

Results

Prevalence of complaints (Study 1)

Of the study population of 106 participants, 69% and 44% reported to have had neck, shoulder or arm symptoms in the previous 12 months and 7 days respectively (figure 1), of which the 12-month prevalence was comparable to the prevalence observed by the occupational physicians. Also for (only) neck symptoms, the occupational physicians observed prevalences close to the 12-month prevalence assessed by the RSI QuickScan. The occupational physicians observed very different numbers of participants with shoulder symptoms, which was also not comparable to what was reported by the participants themselves. In contrast, for elbow complaints the prevalences assessed by questionnaire and reported by the occupational physicians were comparable. Finally, for the forearm/wrist/hand symptoms one occupational physician observed a prevalence close to the 12-month prevalence while the other observed a prevalence close to the 7-day prevalence.

Prevalence of symptoms

Figure 1. *The 12-months and 7-days prevalences of arm, shoulder and neck symptoms – separately and all together (total) – assessed by the RSI QuickScan and prevalences observed by two occupational physicians (study 1).*

Concurrent validity (Study 1)

For the concurrent validity of the RSI QuickScan, the scores of 106 participants on questions concerning the presence of symptoms in the past 7 days were compared to the observations of two occupational physicians, which both observed each participant. Irrespective of body region, the proportion of observed agreement (p_O) between the questionnaire and the occupational physicians was 0.57 and 0.61 for occupational physicians 1 and 2 respectively (figure 2).

(a) Proportion of agreement
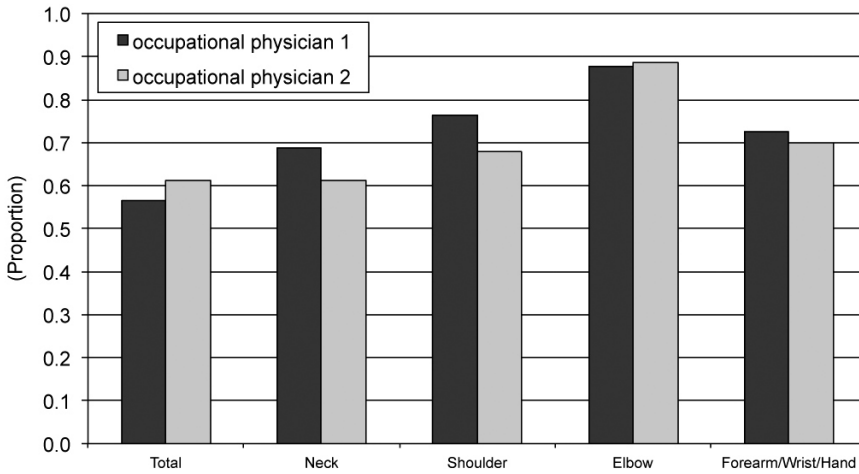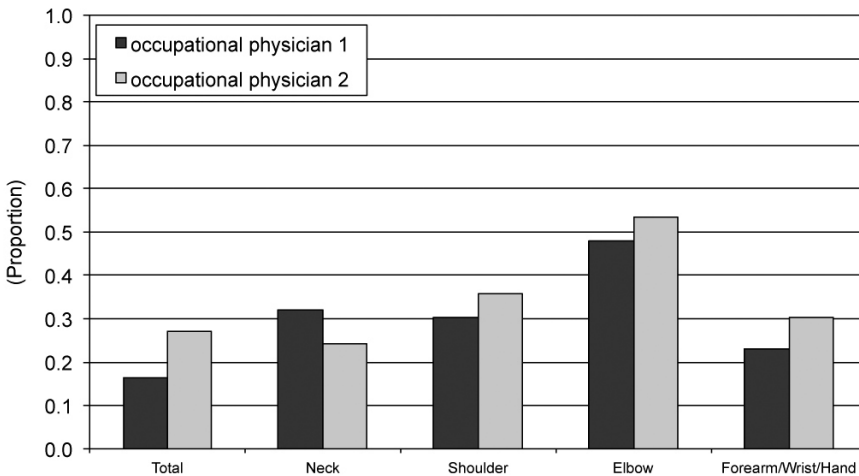
(b) Kappa

(c) Proportion of positive agreement

(d) Proportion of negative agreement

Figure 2. *Concurrent validity of the RSI QuickScan in terms of proportion of agreement, kappa coefficient, proportion of positive agreement and proportion of negative agreement. The scores of 106 participants on questions concerning the presence of complaints in the past 7 days were compared to the observations of two occupational physicians (study 1).*

For the neck, shoulder and forearm/wrist/hand regions the p_O ranged from 0.61 to 0.76. The highest values of p_O were observed for the elbow (0.88-0.89). In terms of kappa coefficients (κ), a similar pattern could be observed, although κ values were low, and were between 0.16 and 0.53 with highest values again observed for the elbow region. For the

observed proportion of positive agreement (p_{pos}), i.e. the agreement on the presence of symptoms, there were no large differences between the different body regions. Highest values of p_{pos} were 0.61 and 0.68 for the presence of symptoms irrespective of body region (total) for occupational physicians 1 and 2 respectively. As was already described for the p_o and κ, also the observed proportion of negative agreement (p_{neg}), i.e. the agreement on the absence of symptoms, showed the lowest values for the body regions taken together (0.51) and the highest values for the elbow region (0.93). Values of p_{neg} were mostly higher than p_{pos}.
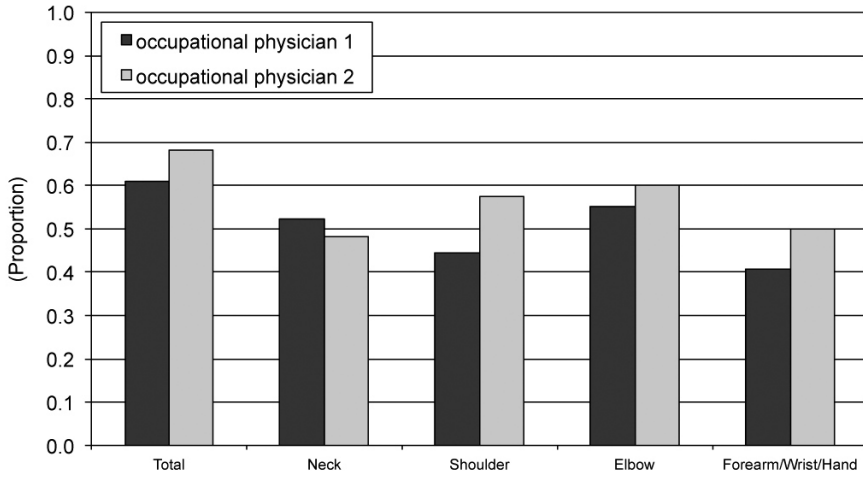
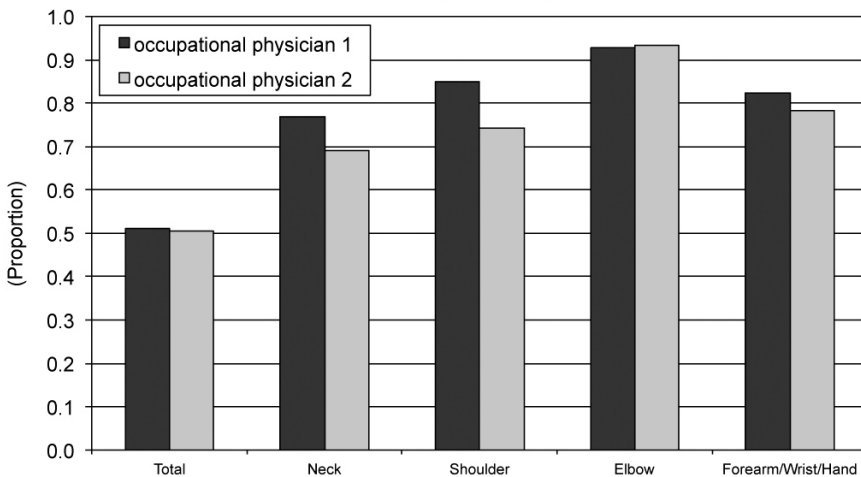**(a) Proportion of agreement**

(b) Kappa

(c) Proportion of positive agreement

(d) Proportion of negative agreement
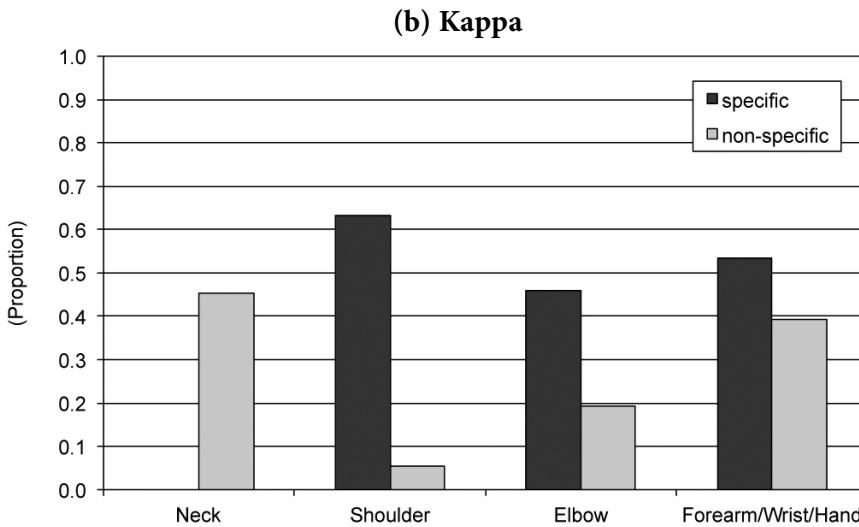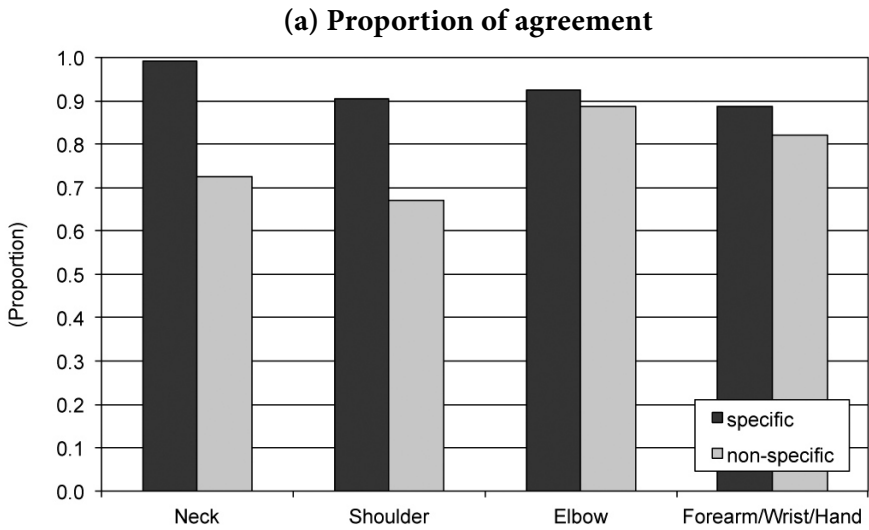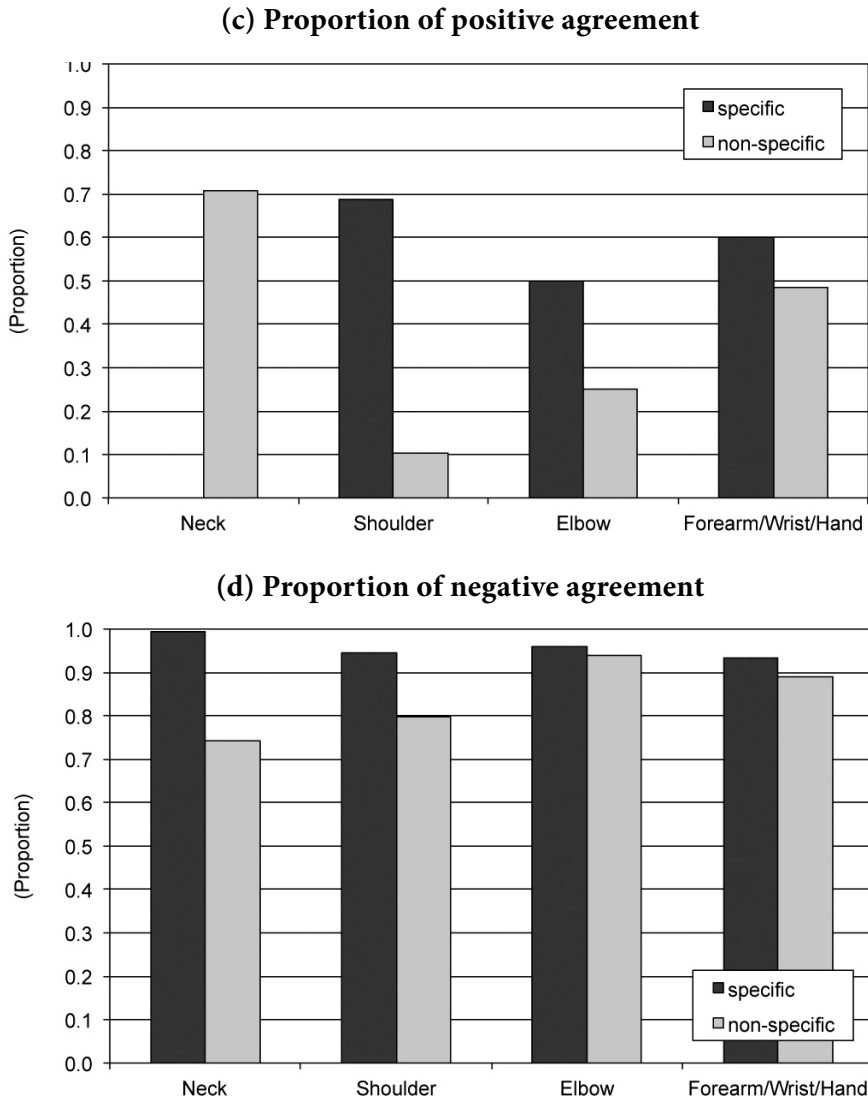
Figure 3. *The inter-observer reliability of the physical examination using the guideline of the Netherlands Society of Occupational Medicine in terms of proportion of agreement, kappa coefficient, proportion of positive agreement and proportion of negative agreement. Results are based on 106 participants, each observed by (the same) two occupational physicians, and for specific and non-specific symptoms of the neck, shoulders or arms (study 1).*

Inter-observer reliability

Study 1

Parameters concerning the concurrent validity generally showed minor differences between the two occupational physicians. Whether the occupational physicians actually agree on a participant is described in figure 3, presenting the inter-observer reliability for specific and non-specific neck, shoulders and arms symptoms separately. For the 106 participants the occupational physicians generally showed high proportions of agreement for specific symptoms (0.89-0.99) and somewhat lower proportions of agreement for non-specific symptoms (0.67-0.89), with lowest values observed for non-specific neck (0.73) and shoulder (0.67) symptoms. Only one participant was observed to have specific neck symptoms by one occupational physician, which resulted in a κ and p_{pos} of zero. Other values of κ were between 0.54 and 0.63 for specific symptoms and between 0.05 and 0.45 for the non-specific symptoms. Furthermore, agreement on the presence of symptoms between the two occupational physicians (p_{pos}) was generally lower than the agreement on the absence of complaints (p_{neg}). Exceptionally low proportions of agreement were found for the presence of non-specific shoulder symptoms and the presence of (specific or non-specific) elbow and forearm/wrist/hand complaints. The observed p_{neg} values were all above 0.70.

Study 2

The results of the inter-observer reliability described above for the study population of 106 participants, in which each participant was observed by the same two occupational physicians, were comparable to the results of the inter-observer reliability for the study population of 11 participants, in which each participant was observed by two occupational physicians out of a group of 15 occupational physicians (figure 4). Calculation of κ and p_{pos} was not always possible because some pairs of occupational physicians observed no symptoms in a specific category (specific neck and forearm/wrist/hand complaints and non-specific elbow symptoms).

(a) Proportion of agreement

(b) Kappa
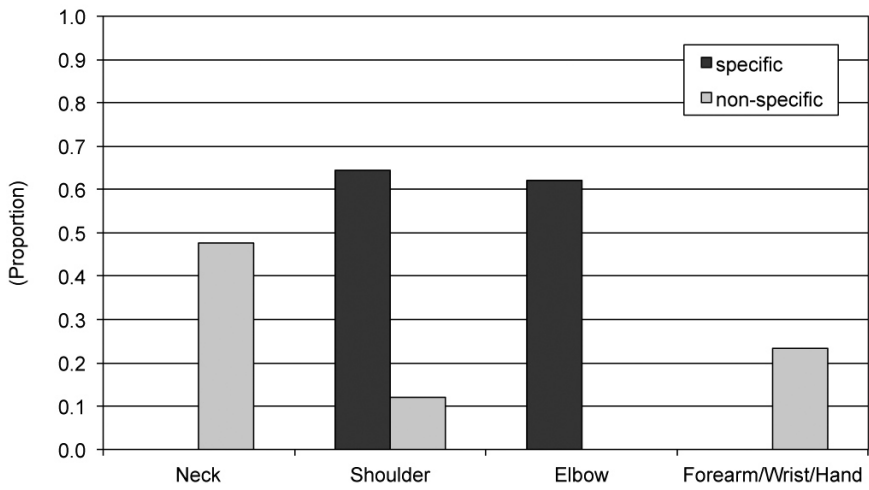
(c) Proportion of positive agreement
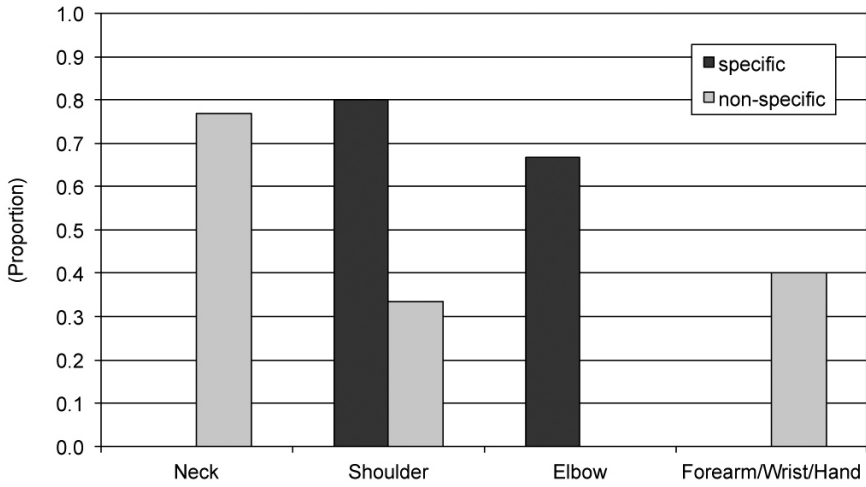
(d) Proportion of negative agreement
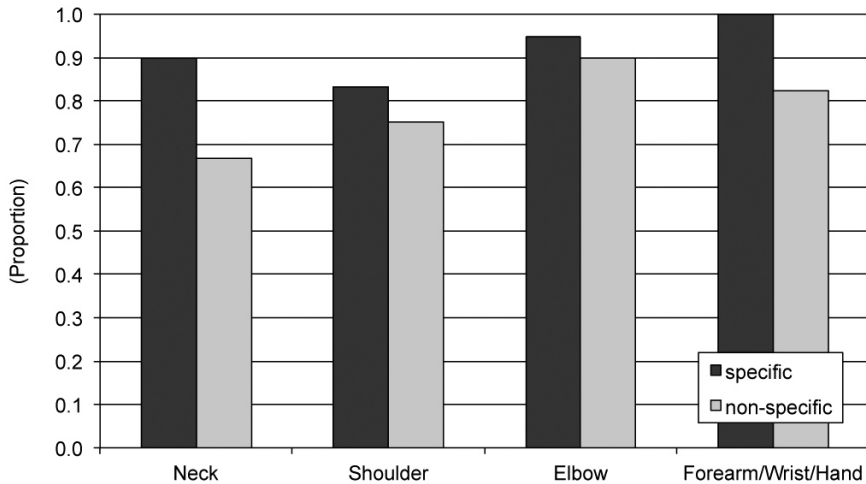
Figure 4. *The inter-observer reliability of the physical examination using the guideline of the Netherlands Society of Occupational Medicine in terms of proportion of agreement, kappa coefficient, proportion of positive agreement and proportion of negative agreement. Results are based on 11 participants, each observed by two occupational physicians from a group of 15 occupational physicians, and for specific and non-specific symptoms of the neck, shoulders or arms (study 2).*
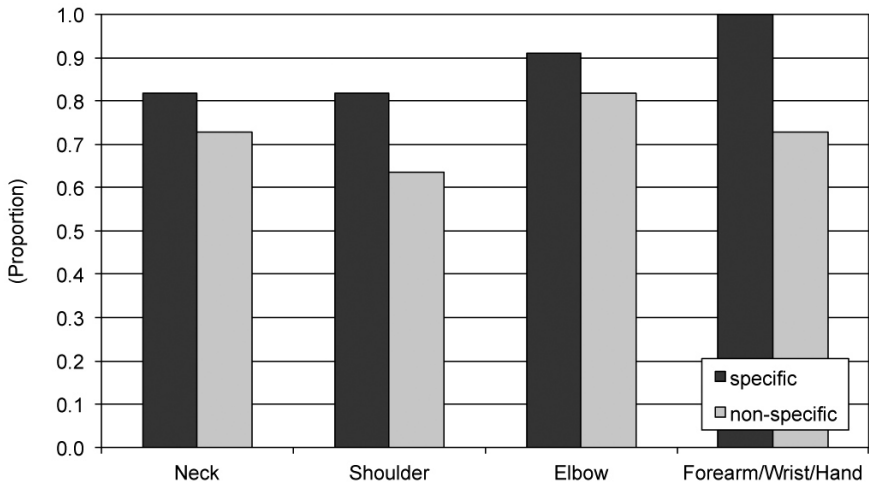
Discussion

In the present study the concurrent validity of the RSI QuickScan was determined by assessing the agreement between the results of questions on the presence of arm, shoulder or neck symptoms and physical examinations by occupational physicians. Results show that overall the concurrent validity of the symptom questions of the RSI QuickScan can be defined as poor to moderate when considering the κ (which was well below 0.60) [32], but, when considering the p_{neg}, that the concurrent validity for detecting the absence of arm, shoulder or neck symptoms can be considered sufficient.

In course of the analyses of the concurrent validity it appeared that the inter-observer reliability was questionable. Therefore, as an additional part of this study also the inter-observer reliability of the physical examinations was investigated. Although the analyses of the inter-observer reliability of the physical examinations generally resulted in relatively high levels of agreement, values of κ, p_{pos} and p_{neg} showed that the occupational physicians agreed sufficiently only on the presence of non-specific neck symptoms, specific shoulder and elbow symptoms and on the absence of non-specific and specific arm, shoulder or neck symptoms.

Validity of using questionnaires for assessment of musculoskeletal symptoms

To assess the prevalence of musculoskeletal symptoms in working populations, questionnaires are frequently used in occupational health care as well as in epidemiological studies. However, the validity of questionnaires compared to more objective methods of assessment, such as physical examinations, has been questioned in the following papers. In a population of 165 female workers, 94 workers (57%) reported symptoms in a questionnaire and were given diagnoses in physical examinations [16]. The sensitivity for the diagnoses was 66-92% while the specificity was 64-88%. The prevalence of symptoms or positive signs observed during the physical examinations was higher than the prevalence of symptoms assessed using the questionnaire. This is in contrast to several other studies that reported higher prevalences for questionnaires compared to physical examinations [17-21]. Other studies report sensitivities of 52-60% [22], 97% for the neck and shoulders [20] and 50-89% [23], and specificities of 86-98%, 41% and 55-89%, respectively. Although not reported in the results section, these values are comparable to values found in the present study with sensitivity ranging 33-70% and specificity ranging 75-94%. Akesson et al. [23] found the sensitivity for the neck/shoulder to be higher than for the elbows/hands/wrists, but this could not be confirmed by the data of the present study. A high correlation between self-reported neck/shoulder symptoms and clinical signs of a neck/shoulder disorder was observed in a cohort of 243 female sewing operators [24]. Among female computer users over 45 years who reported musculoskeletal symptoms

in the neck/shoulder using a questionnaire, 60% was identified by physical examination with a specific diagnosis [25]. However, in the control group that did not report musculoskeletal symptoms, 7% was diagnosed. In the present study, 37-85% of the subjects that reported to have had neck and/or shoulder symptoms in the past 7 days were diagnosed by physical examination and 10-44% of the subjects that not reported to have had symptoms were diagnosed. Finally, for a population of 187 VDU users, Perreault et al. [26] observed a p_o of 0.72 and a κ of 0.44 for the neck/shoulder region, values that are comparable to those observed in the present study.

Clearly, the concurrent validity of the RSI QuickScan questionnaire is comparable to the validity of other questionnaires according to the scientific literature, but can it be considered sufficient? About 80% of the subjects with self-reported symptoms are diagnosed in a physical examination, which can be evaluated as sufficient. It is often argued that physical examinations assess the more severe symptoms, which might explain this finding. However, the occupational physicians found a disorder in about 40% of the subjects without self-reported symptoms. Subjects that were categorized as having no self-reported symptoms included subjects that reported to have had no symptoms at all or only once in the past 7 days (and not long-lasting or regularly). The sensitivity might be increased by categorizing having had symptoms once as having had symptoms or by extending the retrospective period to more than 7 days.

Inter-observer reliability

During the analyses it was noticed that the inter-observer agreement between the two occupational physicians was not optimal and, therefore, the validity of the physical examination could be questioned [33]. Salerno et al. [21] even stated that self-administered measures of upper extremity conditions, such as questionnaires, might be more reliable than physical examination in a population of active workers because results of the physical examination seem to depend on the job content of the study population. In a systematic review of the literature concerning the possible causal relationship between computer work and musculoskeletal symptoms of the neck and upper extremity, Waersted et al. [9] state that finding limited evidence may be partly caused by the selection of only studies with some sort of physical examination performed by a physician, physiotherapist or another trained health professional. They observed that the examination protocols and the resulting diagnoses differed substantially between the included studies. Furthermore, they argue that some of the diagnoses are in a grey zone between subjective complaints and "objective" clinical diagnoses. The exploration of the inter-observer reliability in the present study showed that although the proportions of agreement were relatively high, κ's and the p_{pos}'s were relatively low, with the exception of specific shoulder, elbow and forearm/writs/hand symptoms and non-specific neck symptoms. Toomingas et al. [19] reported κ values of 0.52 and 0.62 for tests of tenderness, range

of motion, pain at isometric muscular contraction and of nerve entrapment, which are comparable values as those reported by Andersen et al. [34] (κ's 0.45-0.57). In another study [21] two experienced examiners physically examined 159 keyboard operators. Although the observed agreement was 96-100%, the corresponding κ values were low and unstable, which the authors attributed to the low prevalence of complaints. The reliability of the Southampton examination schedule, which was developed according to similar criteria as the physical examination protocol that is used in the Netherlands and that was applied in the present study, was studied in patients and in the general population [35, 36]. In a group of 43 patients, 23 of the 31 variables in their schedule showed κ's above 0.40 in the inter-observer reliability analyses [35]. In the general population, 18 of the 33 variables showed κ's above 0.40 [36]. Juul-Kristensen et al. [25] concluded that the reliability of physical examinations was satisfactory with ICC values for specific diagnostic tests varying between 0.21 and 0.76 among a population of elderly female computer users. These results generally indicate that examiners not always agree on their diagnoses.

Limitations of the study

In study 1 of the present study, the two occupational physicians disagreed in 12-35% of the cases, even though they were recently trained in the examination protocol. This raises the question whether examination by occupational physicians is suited to be used as a gold standard. The results of study 1 may not be generalized because of including only two highly trained occupational physicians, which may not be representative of skills of the occupational physicians in the Netherlands. Therefore, study 2 was performed in which 15 occupational physicians participated, who had more experience in working as a occupational physician, but generally did examine patients with arm, shoulder and neck symptoms less frequently. However, also in study 2 the different pairs of occupational physicians disagreed in 9-27% of the cases. In practice, the consequences of misinterpretation/misclassification may be considerable in terms of sick leave, return to work, associated financial costs and personal emotional burden. In addition, it can be discussed which professionals are optimally qualified to perform physical examinations validly as occupational physicians, who did the examinations in the present study and who are the ones to perform the examination in the occupational setting in the Netherlands, are trained in occupational health in general and not in musculoskeletal health specifically. In the literature it was found that physical examinations are performed by (among others) physicians, occupational therapists, physiotherapist, research nurses, rheumatologists, occupational therapists and orthopaedic specialists. Although the scientific literature does not indicate one of these professions as preferable, it is advisable that professionals that daily encounter patients with musculoskeletal symptoms and are specifically trained in diagnostics and treatment perform the physical examinations, which could be the physiotherapists in the Netherlands..

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Another limitation in the present study, besides the examiners, is the study population. The study population consisted of computer workers, for which the RSI QuickScan was designed. Although this sample can be considered as representative for many organizations with computer workers [15] it should be noted that results may not be generalized to other (industrial) occupational populations in which arm, shoulder and neck symptoms occur frequently.

Indices of agreement

The κ values reported in the present study, both the study of the concurrent validity as the study of the inter-observer reliability can be classified as poor to moderate according to Altman [32]. However, as already discussed in several papers [15, 21, 25, 26, 31] the κ statistic is strongly influenced by the observed proportions of individuals who fall in each category of classification (i.e. prevalence) and is considered unstable. Therefore, the p_o and the κ were supplemented with the p_{pos} and p_{neg} as suggested by Cicchetti and Feinstein [31], which are analogous to sensitivity and specificity but are aimed at concordance and not accuracy in an inter-observer reliability study. Generally, these indices show that there is sufficient agreement on the absence of arm, shoulder and neck symptoms between the RSI QuickScan questionnaire and the occupational physicians and between the occupational physicians. However, for the presence of symptoms the agreement between the questionnaire and the occupational physicians can be considered moderate with values around 50%.

Conclusions

In conclusion, the agreement between the symptom questions of the RSI QuickScan questionnaire and physical examinations of occupational physicians can be considered as poor to moderate with κ values between 0.16 and 0.53. However, as the κ could be suspected to be unstable, the p_{pos} and p_{neg} should be considered. Detecting the presence of symptoms (p_{pos}) could be considered as moderately valid with values below 0.60, but the p_{neg} shows that the concurrent validity for detecting the absence of arm, shoulder or neck symptoms can be considered sufficient with values above 0.69. During the study it was noticed that the agreement between occupational physicians can, with a few exceptions, be considered as moderate with κ values below 0.60. But the agreement was sufficient for detecting the absence of symptoms ($p_{neg} > 0.7$). It is advisable to improve the concurrent validity of the symptom questions of the RSI QuickScan as well as the inter-observer reliability of physical examinations as currently applied in the present population of active computer workers.

Acknowledgements

References

[1] **Gerr F, Marcus M, Monteilh C.** *Epidemiology of musculoskeletal disorders among computer users: lesson learned from the role of posture and keyboard use. Journal of Electromyography & Kinesiology. 2004;14(1):25-31.*

[2] **Wahlstrom J.** *Ergonomics, musculoskeletal disorders and computer work. Occupational Medicine (Lond). 2005;55(3):168-76.*

[3] **Buckle P.** *Ergonomics and musculoskeletal disorders: overview. Occupational Medicine (Lond). 2005;55(3):164-7.*

[4] **Brandt LP, Andersen JH, Lassen CF, Kryger A, Overgaard E, Vilstrup I, Mikkelsen S.** *Neck and shoulder symptoms and disorders among Danish computer workers. Scandinavian Journal of Work, Environment & Health. 2004;30(5):399-409.*

[5] **Ekman A, Andersson A, Hagberg M, Hjelm EW.** *Gender differences in musculoskeletal health of computer and mouse users in the Swedish workforce. Occupational Medicine (Lond). 2000;50(8):608-13.*

[6] **Palmer KT, Cooper C, Walker-Bone K, Syddall H, Coggon D.** *Use of keyboards and symptoms in the neck and arm: evidence from a national survey. Occupational Medicine (Lond). 2001;51(6):392-5.*

[7] **Punnett L, Bergqvist U.** *Musculoskeletal disorders in visual display unit work: gender and work demands. Occupational Medicine. 1999;14(1):113-24, iv.*

[8] **IJmker S, Huysmans MA, Blatter BM, Van der Beek AJ, Van Mechelen W, Bongers PM.** *Should office workers spend fewer hours at their computer? A systematic review of the literature. Occupational and Environmental Medicine. 2007;64(4):211-22.*

[9] **Waersted M, Hanvold TN, Veiersted KB.** *Computer work and musculoskeletal disorders of the neck and upper extremity: a systematic review. BMC Musculoskeletal Disorders. 2010;11:79.*

[10] **Klein Hesselink J, Houtman I, Hooftman W, Bakhuys Roozeboom M.** *Arbobalans 2009. Kwaliteit van de arbeid, effecten en maatregelen in Nederland. Hoofddorp: TNO Kwaliteit van Leven; 2009.*

[11] **Bakhuys Roozeboom M, De Vroome E, Smulders P, Van den Bossche S.** *TNO Arbeidssituatie Survey 2000-2004. Trends in de arbeid in Nederland tussen 2000 en 2004. Hoofddorp: TNO Kwaliteit van Leven; 2007.*

[12] **Bongers PM.** *Maak werk van RSI: Inaugural speech, VU Medical Centre, Amsterdam 2003.*

[13] **Blatter B, Houtman I, Van den Bossche S, Kraan K, Van den Heuvel S.** *Gezondheidsschade en kosten als gevolg van RSI en psychosociale arbeidsbelasting in Nederland [Health effects and costs due to RSI and psychosocial workload in the Nederlands]. Den Haag: Ministerie van Sociale Zaken en Werkgelegenheid; 2005.*

[14] **Speklé EM, Hoozemans MJ, Blatter BM, Heinrich J, Van der Beek AJ, Knol DL, Bongers PM, Van Dieen JH.** *Effectiveness of a questionnaire based intervention programme on the prevalence of arm, shoulder and neck symptoms, risk factors and sick leave in computer workers: a cluster randomised controlled trial in an occupational setting. BMC Musculoskeletal Disorders. 2010;11:99.*

[15] **Speklé EM, Hoozemans MJ, Van der Beek AJ, Blatter BM, Bongers PM, Van Dieen JH.** *Internal consistency, test-retest reliability and concurrent validity of a questionnaire on work-related exposure related to arm, shoulder and neck symptoms in computer workers. Ergonomics. 2009;52(9):1087-103.*

[16] **Ohlsson K, Attewell RG, Johnsson B, Ahlm A, Skerfving S.** *An assessment of neck and upper extremity disorders by questionnaire and clinical examination. Ergonomics. 1994;37(5):891-7.*

[17] **Zetterberg C, Forsberg A, Hansson E, Johansson H, Nielsen P, Danielsson B, Inge G, Olsson BM.** *Neck and upper extremity problems in car assembly workers. A comparison of subjective complaints, work satisfaction, physical examination and gender. International Journal of Industrial Ergonomics. 1997;19(4):277-89.*

[18] **Nordander C, Ohlsson K, Balogh I, Rylander L, Palsson B, Skerfving S.** *Fish processing work: the impact of two sex dependent exposure profiles on musculoskeletal health. Occupational and Environmental Medicine. 1999;56(4):256-64.*

[19] **Toomingas A, Nemeth G, Alfredsson L.** *Self-administered examination versus conventional medical examination of the musculoskeletal system in the neck, shoulders, and upper limbs. The Stockholm MUSIC I Study Group. Journal of Clinical Epidemiology. 1995;48(12):1473-83.*

[20] **Bjorksten MG, Boquist B, Talback M, Edling C.** *The validity of reported musculoskeletal problems. A study of questionnaire answers in relation to diagnosed disorders and perception of pain. Applied Ergonomics. 1999;30(4):325-30.*

[21] **Salerno DF, Franzblau A, Werner RA, Chung KC, Schultz JS, Becker MP, Armstrong TJ.** *Reliability of physical examination of the upper extremity among keyboard operators. American Journal of Industrial Medicine. 2000;37(4):423-30.*

[22] **Stål M, Moritz U, HJohnsson B, Pinzke S.** *The natural course of musculoskeletal symptoms and clinical findings in upper extremities of female milkers. International Journal of Occupational and Environmental Health. 1997;3:190-7.*

[23] **Akesson I, Johnsson B, Rylander L, Moritz U, Skerfving S.** *Musculoskeletal disorders among female dental personnel--clinical examination and a 5-year follow-up study of symptoms. International Archives of Occupational and Environmental Health. 1999;72(6):395-403.*

[24] **Kaergaard A, Andersen JH, Rasmussen K, Mikkelsen S.** *Identification of neck-shoulder disorders in a 1 year follow-up study. Validation Of a questionnaire-based method. Pain. 2000;86(3):305-10.*

[25] **Juul-Kristensen B, Kadefors R, Hansen K, Bystrom P, Sandsjo L, Sjogaard G.** *Clinical signs and physical function in neck and upper extremities among elderly female computer users: the NEW study. European Journal of Applied Physiology. 2006;96(2):136-45.*

[26] **Perreault N, Brisson C, Dionne CE, Montreuil S, Punnett L.** *Agreement between a self-administered questionnaire on musculoskeletal disorders of the neck-shoulder region and a physical examination. BMC Musculoskeletal Disorders. 2008;9:34.*

[27] **Verbeek JAHM, Broekkamp CW, Van Cuilenburg LC, Van Heijst AJP, Kramer E, Kremer EAJM, Rutten RGHM, Tellekamp JJ, Verhoeven ACLPJ.** *Practice guidline for occupational physicians on the management of employees with complaints of arm, shoulder or neck. Utrecht, The Netherlands: NVAB 2003.*

[28] **Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sørensen F, Andersson G, Jorgensen K.** *Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Applied Ergonomics. 1987;18(3):233-7.*

[29] **Sluiter JK, Rest KM, Frings-Dresen MH.** *Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders. Scandinavian Journal of Work, Environment & Health. 2001;27 Suppl 1:1-102.*

3

[30] **Feinstein AR, Cicchetti DV.** *High agreement but low kappa: I. The problems of two paradoxes. Journal of Clinical Epidemiology. 1990;43(6):543-9.*

[31] **Cicchetti DV, Feinstein AR.** *High agreement but low kappa: II. Resolving the paradoxes. Journal of Clinical Epidemiology. 1990;43(6):551-8.*

[32] **Altman DG.** *Practical statistics for medical research. 1st ed. London: Chapman & Hall 1991.*

[33] **Marx RG, Bombardier C, Wright JG.** *What do we know about the reliability and validity of physical examination tests used to examine the upper extremity? Journal of Hand Surgery. 1999;24(1):185-93.*

[34] **Andersen JH, Kaergaard A, Frost P, Thomsen JF, Bonde JP, Fallentin N, Borg V, Mikkelsen S.** *Physical, psychosocial, and individual risk factors for neck/shoulder pain with pressure tenderness in the muscles among workers performing monotonous, repetitive work. Spine (Phila Pa 1976). 2002;27(6):660-7.*

[35] **Palmer K, Walker-Bone K, Linaker C, Reading I, Kellingray S, Coggon D, Cooper C.** *The Southampton examination schedule for the diagnosis of musculoskeletal disorders of the upper limb. Annals of the Rheumatic Diseases. 2000;59(1):5-11.*

[36] **Walker-Bone K, Byng P, Linaker C, Reading I, Coggon D, Palmer KT, Cooper C.** *Reliability of the Southampton examination schedule for the diagnosis of upper limb disorders in the general population. Annals of the Rheumatic Diseases. 2002;61(12):1103-6.*

4

The predictive validity of the RSI QuickScan questionnaire with respect to arm, shoulder and neck symptoms in computer workers

The predictive validity of the RSI QuickScan questionnaire with respect to the prevalence of arm, shoulder and neck symptoms in computer workers.

Abstract

Introduction: The aim of this study was to determine whether results from the RSI QuickScan questionnaire on risk factors for arm, shoulder and neck symptoms can predict future arm, shoulder and neck symptoms in a population of computer workers.

Methods: For this prospective cohort study, with a follow-up of 24 months, 3383 workers who regularly worked with a computer were approached. Generalized Estimating Equations (GEE) with 6, 12, 18 and 24 months time lags were used to determine whether high exposure was related to symptoms at follow-up.

Results: The results showed that high scores on 9 out of 13 scales, including previous symptoms, were significantly related to arm, shoulder and neck symptoms at follow-up.

Conclusions: These results provide support for the predictive validity of the RSI QuickScan questionnaire.

Introduction

Information and communication technology (ICT) plays an ever more important role in the current workplace and as a result computer use has greatly increased in recent decades [1-3]. Unfortunately, arm, shoulder and neck symptoms are common amongst computer workers and are suggested to be work-related [4-10]. These symptoms vary in severity, from mild to very severe, and have become one of the most important causes of work disability [11, 12]. The total yearly costs of arm, shoulder and neck symptoms are high [13-16] and employers are trying to reduce these costs by implementing interventions aimed at reducing exposure to risk factors and, thereby, the prevalence of symptoms.

   Some employers are concerned that screening, education and focused attention on work-related musculoskeletal symptoms will cause an increase in these symptoms and the incidence of workers' compensation claims. However, a prospective cohort study by Melhorn et al. [17] demonstrated that there was no increase in the number of reported work-related injuries and no increase in the incidence of workers' compensation claims after completion of an individual risk screening program that included education and employee awareness about work-related musculoskeletal pain. Moreover, incidence of cumulative trauma disorders has been most effectively reduced by use of individual risk-screening programs [17]. Several programs have, therefore, been developed that include individual risk screening aimed at asymptomatic or symptomatic workers. As a first example, consider a major aircraft manufacturer that implemented a risk-assessment program in a population of asymptomatic assembly workers [18]. The program focused on objectively identifying the relationship of work and other activities to an individual worker experiencing arm, shoulder and neck symptoms. The results indicated that risk can be identified in individual workers and that ergonomic posture training in high-risk workers was associated with reduced levels of risk. As a second example, consider a study performed by Feuerstein and co-workers [19], in which a tool for use in a clinical setting to assist in identifying symptomatic workers at risk for poorer outcome was developed. The results indicated that baseline measures of ergonomic and psychosocial stress, pain severity, and pain coping style predict clinical outcome at shorter intervals, whereas number of past treatments/providers, recommendation for surgery and pain coping style predict longer-term outcome. The resulting prognostic screen provides a simple tool that assesses the multidimensional nature of work-related upper extremity disorders and predicts clinical outcome. As a third example, consider a study performed by Dane and co-workers [20], in which the measurement properties of an upper-extremity–specific self-report index of ergonomic exposures in a population of symptomatic office workers were examined. The results indicated that higher levels of self-reported ergonomic

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exposures were associated with upper extremity pain, symptom severity, and functional limitations.

In the present study the predictive validity of the questionnaire of the RSI QuickScan intervention programme is investigated [21].The RSI QuickScan intervention programme differs from the three aforementioned programmes, because it is designed for populations consisting of both asymptomatic and symptomatic computer workers. Its goal is to identify individuals with high risks and/or symptoms, reduce exposure to presumed risk factors and, consequently, the prevalence of arm, shoulder and neck symptoms [21]. The intervention starts with the assessment of the presence or absence of potential risk factors in a company or organisation. The risk factors that are assessed have previously been recognized in etiological studies, such as work posture and movement, job decision latitude, relation with management and colleagues, work pace and load, work environment factors and furniture [10, 22-36]. Furthermore, research showed that having had previous arm, shoulder and neck symptoms is associated with future symptoms [37-39]. Arm, shoulder and neck symptoms at baseline are, therefore, also assessed with the RSI QuickScan questionnaire, as this information can be used in identifying workers at risk of also having symptoms at a later date. The assessment of risk factors and symptoms using this internet-based instrument was found to be reliable and valid and can be used as a means to rapidly collect data on a large population of office workers [40]. The questionnaire is used as a screening tool and aims to identify workers with a high risk. After the worker has filled out the questionnaire, the total score of the individual worker on each scale is classified into two categories: low to medium or high risk. For workers with a high level of exposure to risk factors and/or with arm, shoulder and neck symptoms individual feedback and advice on the specific actions that they can personally take in order to reduce their risk, are offered [21].

The assumption underlying this approach is that high exposure and previous symptoms as scored with the questionnaire predict future symptoms. The aim of the present study was to test this assumption. Much research has been done on risk factors for arm, shoulder and neck symptoms [41-44]. Ideally, such etiological studies are performed in a population without symptoms at baseline and evaluate subsequent incidences. The present study was designed to stay close to the aims of the RSI QuickScan intervention programme as it is used in practice. We therefore did not select a study population without symptoms at baseline. Populations in most organisations are a blend of workers with and without arm, shoulder and neck symptoms. Since the prevalence of arm, shoulder and neck symptoms is high, secondary as well as primary prevention are important and the RSI QuickScan programme is targeted at all workers with a high risk of having symptoms at a later date. The RSI QuickScan questionnaire has been used as a screening tool for several years, but the predictive validity of the scales in the questionnaire has not previously been determined. Therefore, the aim of this study was to

determine whether results from the RSI QuickScan questionnaire can predict future arm, shoulder and neck symptoms in a population of computer workers.

4

Methods

Study design and follow-up

This study was designed as an observational, prospective cohort study. None of the participants was involved in any intervention whatsoever. Data on exposure to risk factors for arm, shoulder and neck symptoms and the prevalence of arm, shoulder and neck symptoms were collected with the RSI QuickScan questionnaire at baseline, and after 6, 12, 18 and 24 months. The internet-based RSI QuickScan investigates the presence or absence of potential risk factors, such as work posture and movement, job decision latitude, relation with management and colleagues, work pace and load, work environment factors, and furniture [40]. A detailed description of the questionnaire can be found at *www.rsiquickscan.com/research/questionnaire.pdf.*

Participation was voluntarily and all participants electronically provided informed consent before filling out the baseline questionnaire. In case of non-response, participants received a maximum of two reminders by e-mail. The study design, protocols, procedures and informed consent form were approved by the Ethics Committee of the Faculty of Human Movements Sciences of the VU University Amsterdam.

Population

The source population consisted of office staff, consultants, health care personnel, researchers and managers (N = 3383) of an Occupational Health Service (Arbo Unie), with offices throughout the Netherlands. This population works considerably more than two hours with the computer per day (data not presented) and is, therefore, termed computer worker. Workers with and without arm, shoulder and neck symptoms were included. The workers were contacted by e-mail and were given time during work to fill out the questionnaires.

Data collection procedure

The workers were informed about the study using the Intranet site of the organisation and through the companies' magazine. In addition, all these employees received an e-mail with information on the objectives of the study, privacy as well as required effort for participation. Data on exposure to risk factors and the prevalence of arm, shoulder and neck symptoms was collected using an internet-based questionnaire. The workers were contacted by e-mail and were given time during work to fill out the questionnaires. Participants received an e-mail containing a link to the questionnaire, their ID-number and password. The questionnaire consisted of several items on work, work place, and musculoskeletal health (98 items in total). By request, they were sent a hard copy of the questionnaire by regular post. The workers were given time during work to fill out the

questionnaires. As incentive for participation, workers who participated in all five meas-
urements were included in a lottery for a weekend holiday in Paris.

Assessment of risk factors

The internet-based RSI QuickScan investigates the presence or absence of potential risk
factors, such as work posture and movement, job decision latitude, relation with manage-
ment and colleagues, work pace and load, work environment factors, and furniture [40].
The questionnaire included questions on: information on computer work and health,
work hours, work posture and movement, work tasks, job decision latitude, work relation
with management and colleagues, work pace and load, recovery time, work environment
factors, furniture, and computer workstation physical attributes. In accordance with the
rationale for intervention allocation in the RSI QuickScan programme, high risk was
defined as a score of 61% or more on the maximum of each scale. The questionnaire has
been described in more detail previously [40] and can be found at *www.rsiquickscan.com/
research/questionnaire.pdf*

Assessment of symptoms

The 6-month prevalence of arm, shoulder and neck symptoms was assessed using modi-
fied questions of the Standardised Nordic questionnaire [45], which specifies seven
(instead of five in the Nordic Questionnaire) areas in the upper extremity region (neck,
upper back, shoulder, elbow, forearm, wrist, hand), as suggested by Sluiter et al. [46].
Workers had to answer the question: 'Have you had trouble (aches, pain, discomfort)
in the neck, upper back, shoulders, elbows, lower arms, wrist or hand in the previous
6-months?', with one of the following four response options: 'No, never'; 'Yes, sometimes';
'Yes, regularly'; 'Yes, prolonged'. A case of arm, shoulder and neck symptoms was defined
as reporting regular or prolonged symptoms, in one or more of the seven regions, in the
previous 6 months.

Statistics

To determine whether the RSI QuickScan questionnaire is able to predict the future
prevalence of arm, shoulder and neck symptoms in a population of computer workers,
Generalized Estimating Equations (GEE) were used, which is an extension of generalized
linear models that accounts for correlated repeated measurements within individuals
[47-50], with 6, 12, 18 and 24 months time lags. At all five time points, exposure to risk
factors and the prevalence of arm, shoulder and neck symptoms were measured. The
GEE time lag model was used to evaluate whether high scores on risk factors and the
prevalence of arm, shoulder and neck symptoms were related to the arm, shoulder and
neck symptoms reported 1, 2, 3 or 4 surveys later, thus taking into account the temporal
sequence of cause and effect [51, 52]. Figure 1 shows the 6, 12, 18 and 24 month time

lag models, where the dependent variable (Y) is arm, shoulder and neck symptoms, and the independent variables (X) are the risk factors and previous arm, shoulder and neck symptoms.

In univariate analyses crude odds ratios (OR) with corresponding 95% confidence intervals (95% CI) were calculated for all risk factors studied, including previous symptoms, for all time lags. Differences between the respondents and non-respondents at T1 were examined with the chi square analyses. An alpha level of 0.05 was used. All analyses were conducted using SPSS version 16 [53].
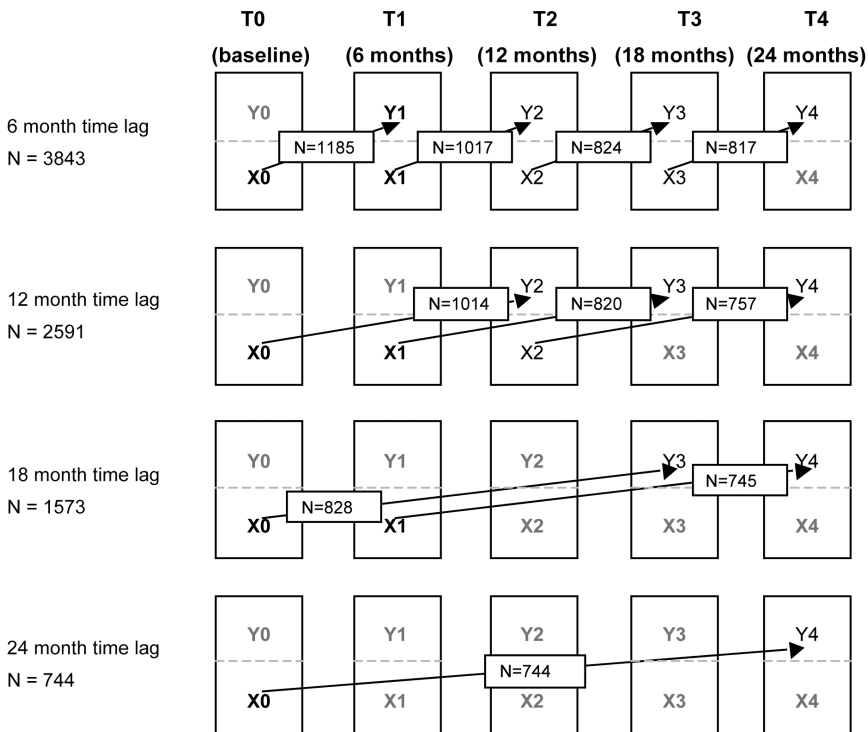
Figure 1. *Illustration of the generalized estimating equations (GEE) with 6, 12, 18 and 24 month time lag models. The number of workers is represented for each of the tested associations. Y is the dependent variable and X is the independent variable. T0 = baseline, T1 = 6 months, T2 = 12 months, T3 = 18 months and T4 = 24 months, after baseline.*

Results

Response

At baseline, 3383 workers were contacted by e-mail and in total 2660 workers partici-pated in one or more of the five measurements. Of the 3383 workers, 2049 (61%) workers filled out the questionnaire at baseline (T0), 1485 (44%) at the second (T1), 1278 (38%) at the third (T2), 1195 (35%) at the fourth (T3) and 1043 (31%) workers filled out the questionnaire at the fifth (T4) measurement (Table 1). In total, 7050 completed question-naires were received over the two year period. Of the 2660 workers who participated in one or more of the five measurements, 872 (32.8%) workers filled out only one question-naire, 543 (20.4%) workers filled out two questionnaires, 401 (15.1%) workers three, 331 (12.4%) workers four, and 513 (19.3%) workers filled out all five questionnaires. In total 1788 workers answered two or more questionnaires and entered into the investigation.

Non-response analysis

There were no significant differences between the respondents and non-respondents at T1 with regard to the outcome variable prevalence of arm, shoulder and neck symp-toms in the previous 6-months, nor were there significant differences in age and gender between respondents and non-respondents. However, there were significant differ-ences between respondents and non-respondents with regard to 4 of the 12 risk factors. Non-respondents at follow-up (T1) had significantly lower risk scores on the scales 'information', 'work tasks', 'work relations with management and colleagues', but a higher risk score on 'job decision latitude'. Figure 1 shows the number of workers represented in each of the tested associations.

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Table 1: *Characteristics of the study population for each of the five measurements*

	T0 (N=2049)	T1 (N=1485)	T2 (N=1278)	T3 (N=1195)	T4 (N=1043)
Gender (male)	648 (31.6%)	491 (33.1%)	409 (32.0%)	452 (37.8%)	402 (38.5%)
Age (years) (mean, SD)	42.6 (9.3)	43.0 (9.1)	43.1 (9.2)	43.7 (8.9)	44.0 (8.9)
Risk factors (% workers with a high risk)					
Information	49.3	44.2	41.0	46.0	46.7
Work hours	6.2	5.4	5.1	6.6	7.6
Work posture and movement	15.1	12.4	10.3	11.0	8.7
Work tasks	19.1	15.8	16.1	14.5	16.6
Job decision latitude	6.9	6.9	7.5	9.5	9.5
Work relation with management and colleagues	13.5	13.3	16.3	22.0	18.7
Work pace and load	38.3	34.7	35.3	36.9	45.8
Recovery time	8.8	7.5	10.0	11.6	12.3
Work environmental factors	7.2	8.0	5.8	5.2	5.5
Furniture	5.5	3.2	4.4	3.5	4.0
Computer workstation physical attributes	3.5	3.9	3.8	3.1	4.5
Eyesight	37.0	32.8	29.9	30.1	30.7
Arm, shoulder and neck symptoms					
Prevalence symptoms (%)	59.1	51.3	48.4	48.0	61.5

Associations between high exposure and the 6 month prevalence of symptoms to arm, shoulder and neck symptoms at follow-up

The GEE analyses with 6, 12, 18 and 24 month time lags (Table 2) showed a significantly higher probability of reporting future arm, shoulder and neck symptoms, with ORs at different time lags ranging from 1.3 to 3.1, for the scales: 'work posture and movement', 'work tasks', 'job decision latitude', 'work relation with management and colleagues', 'work pace and load', 'recovery time', 'work environmental factors', 'furniture', 'eyesight', and previous 'arm, shoulder and neck symptoms'. For the remaining scales (information, work hours, and computer workstation physical attributes) having a high risk score on these factors did not increase the risk of reporting arm, shoulder and neck symptoms in the future.

Associations between previous symptoms and future arm, neck and shoulder symptoms

Results of the GEE analyses with a 6, 12, 18 and 24 month time lag (Table 2) showed that previous arm, shoulder and neck symptoms were significantly related, to a higher risk (ORs ranging from 4.1 - 6.6) of future arm, shoulder and neck symptoms.

Comparison of the results with different time lags

The GEE analyses (Table 2) showed consistent results for all four time lags, except for the scale on work environment factors and the scale on furniture. The scales on work posture and movement, work tasks, work pace and load, recovery time, work environment factors, eyesight and symptoms showed ORs greater than 1 for all four time lags. The risk estimates for the scales work posture and movement, works tasks and recovery time showed a steady increase over time. However, the overall number of significant ORs for the scales decreased with longer, 18- and 24-months time lags (Table 2).

Table 2. *Results for four different time lags concerning the relation between risk factors and previous symptoms on the one hand and for future arm, shoulder and neck symptoms on the other.*

GEE time lag model	6 months OR (95% CI)	12 months OR (95% CI)	18 months OR (95% CI)	24 months OR (95% CI)
Risk factors				
Information	0.95 (0.83 - 1.08)	0.95 (0.82 - 1.12)	0.89 (0.73 - 1.08)	1.08 (0.80 - 1.45)
Work hours	1.21 (0.94 - 1.56)	1.21 (0.87 - 1.68)	1.03 (0.68 - 1.55)	0.75 (0.43 - 1.32)
Work posture and movement	1.27 (1.20 - 1.69)	1.55 (1.25 - 1.91)	1.74 (1.29 - 2.37)	2.04 (1.26 - 3.31)
Work tasks	1.42 (1.06 - 1.52)	1.41 (1.14 - 1.76)	2.06 (1.53 - 2.77)	2.41 (1.45 - 4.00)
Job decision latitude	1.29 (1.00 - 1.65)	1.58 (1.14 - 2.19)	1.68 (1.09 - 2.57)	1.30 (0.65 - 2.62)
Work relation with management and colleagues	1.33 (1.13 - 1.57)	1.57 (1.27 - 1.95)	1.07 (0.81 - 1.43)	1.08 (0.68 - 1.72)
Work pace and load	1.26 (1.11 - 1.44)	1.30 (1.11 - 1.52)	1.23 (0.99 - 1.52)	1.34 (0.99 - 1.82)
Recovery time	1.70 (1.36 - 2.12)	1.81 (1.37 - 2.40)	1.82 (1.26 - 2.61)	3.15 (1.57 - 6.32)
Work environment factors	1.34 (1.06 - 1.69)	1.06 (0.79 - 1.43)	1.50 (1.00 - 2.27)	1.76 (0.92 - 3.38)
Furniture	0.95 (0.69 - 1.32)	1.87 (1.22 - 2.88)	0.94 (0.57 - 1.55)	1.27 (0.59 - 2.73)
Computer workstation physical attributes	1.20 (0.84 - 1.71)	1.06 (0.73 - 1.54)	0.84 (0.51 - 1.39)	0.71 (0.35 - 1.43)
Eyesight	1.38 (1.20 - 1.59)	1.71 (1.44 - 2.03)	1.63 (1.32 - 2.03)	1.59 (1.15 - 2.20)
Previous symptoms				
Arm, shoulder and neck symptoms	6.63 (5.61 - 7.83)	4.49 (3.72 - 5.41)	4.05 (3.24 - 5.06)	4.71 (3.43 - 6.48)

The GEE analyses with a 6, 12, 18 and 24 months time lag model, show the odds ratios (OR) with 95% confidence intervals (95% CI) for arm, shoulder and neck symptoms after 6, 12, 18 and 24 months of follow-up.

Discussion

Summary and interpretation of findings

The aim of this study was to determine whether results from the RSI QuickScan questionnaire on risk factors for arm, shoulder and neck symptoms can predict the future prevalence of arm, shoulder and neck symptoms. The results indicate that most scales of the RSI QuickScan questionnaire are valid tools to predict future prevalence of arm, shoulder and neck symptoms in computer workers.

Missing data

To analyze the missing data (intermittent missing data and drop-outs) in our study population, we compared the differences in the outcome variable arm, shoulder and neck symptoms as well as age, gender and risk factors at baseline, between the respondents and non-respondents at T1. Since the drop-out between T0 and T1 was larger than the combined drop-out of T2, T3 and T4, and since there were no indications of differences in later drop-out, no further drop-out analysis was performed. We found no differences in the prevalence of arm, shoulder and neck symptoms, suggesting that there was no health-based selection in our study population. Nor were there differences in age and gender. Yet the non-respondents at follow-up had significantly lower risk scores on the scales 'information', 'work tasks', 'work relations with management and colleagues', but a higher risk score on 'job decision latitude', suggesting that there might have been some selection in our study population. This may have violated the 'missing completely at random' (MCAR: missing, independent of both unobserved and observed data) assumption in our analyses and may have caused some bias to our estimates [47, 54]. However, since the pattern on the occurrence of arm, shoulder and neck symptoms during follow-up is assumed to be random, the effect of this potential bias is believed to be limited. Missing data were not imputated, because when GEE is used to analyze a longitudinal dataset with missing data, imputing missing data with longitudinal imputation methods (i.e., last value carried forward, longitudinal interpolation, and longitudinal regression) or multiple imputation, may lead to an under- or overestimating of the standard errors, depending on the chosen imputation method. Therefore, not imputing at all may be better than any of these imputation methods [55]. During the two years of the study, the participating organization downsized considerably and reduced its workforce by approximately 30%. This process, which was independent of the predictor and outcome variables, caused many participants to involuntarily leave the study and was a major contributor to the drop-out.

4

Strengths and limitations of the study

An important strength of our study is its prospective design, with five measurements over a two year period. This design allowed for repeated measurements of exposure that adjust for changes in the workplace that might occur in a two-year period. To study the predictive validity of our method of assessment we needed to stay as close as possible to the intervention program as used in practice. Therefore, we have chosen not to adjust for the influence of other variables, such as previous arm, shoulder and neck symptoms, as might be preferable for an etiological study. The discussion on what causes arm, shoulder and neck symptoms is still ongoing. It is, however, clear that these symptoms are highly prevalent among computer workers and many computer workers have suffered from arm, shoulder and neck symptoms at a certain point in time [56, 57]. The high prevalence of symptoms at all five time points also shows that if the data were used for an etiological study, selecting a true symptom-free population would have been difficult due to the episodic nature of these symptoms. Even though this study had a longitudinal design, our decision not to adjust for other factors caused that we refrained from drawing conclusions on etiology.

In this study the scale on previous symptoms is used both as a risk factor and as an outcome measure. This may be considered a flaw in the design of the study. However, previous symptoms can be predictors of current symptoms either because symptoms have become chronic or because they are recurrent. In this context, using the same measurement tool to asses the predictor and outcome seems actually preferable. It could also be argued that previous questions in the RSI QuickScan may bias later questions. However, there is no conclusive evidence that question-order affects response [58]. Generally, it is believed that question-order effects exist in interviews, but not in written surveys. In the case of online questionnaires, such as the RSI QuickScan, using the 'screen-by-screen approach' provides less context than people normally have for answering questions, when compared to paper questionnaires. Observations of respondents answering questions that appeared one at a time on screens suggested that some respondents lost a sense of context [59]. In the case of RSI QuickScan questionnaire, respondents answer a number of questions about their work environment. However, it is debatable whether the respondents will perceive their answers as high risk (and therefore are more likely to report symptoms in order to be consistent). Furthermore, separating the outcome from the instrument, i.e. in another questionnaire might not solve this problem. It may, however, introduce negative effects, i.e. an increased non-response rate.

For practical reasons we performed this study in one company and one could argue that it might have been better for the generalization of the results if more organizations were included in this study. However, this was a fairly large organization (N = 3383), with offices throughout the Netherlands and with a broad range of computer workers with diverse educational levels, ranging from intermediate to university education.

Exposure to risk factors were similar to scores in other organizations, e.g. the scores in our intervention study [21]. The age of the study population was representative for a working population and ranged between 21 and 66 years. Even though females were overrepresented compared to the general population, with two thirds being female, this is representative for many organizations with computer workers. One final limitation may be that the GEE method does not correct for feedback bias that may occur with repeated measurements of exposures and outcome variables, where earlier outcomes may affect subsequent exposure [60]. However, such effects are likely to be limited given the 6 months period between filling out questionnaires.

Risk factors and symptoms

Little research has been done on the predictive validity of risk factors and previous symptoms for arm, shoulder and neck symptoms [61]. Unfortunately, no comparable studies were found, in which the predictive validity of a questionnaire on risk factors and previous symptoms to arm, shoulder and neck symptoms at follow-up was investigated in a population of computer workers with and without symptoms. The concurrent validity of the questions on arm, shoulder and neck symptoms has been investigated and the results suggest that the symptom questions in the RSI QuickScan are moderately suited to detect the prevalence of symptoms, but well suited to detect the absence arm, shoulder and neck symptoms (results not published).

In a previous reliability study [40], each item of the subscales was tested separately and consequently no reliability study was performed with the cut-off scores for the sub-scales that are used at present. However, multi-item scales, even short ones, are more reliable than the single items [62]. Therefore, the results in our previous study are likely to be conservative and no additional analysis was performed.

The results with regard to the risk factors: work posture and movement, work tasks, job decision latitude, work relation with management and colleagues, work pace and load, recovery time, work environmental factors and eyesight, were found to be statistically significant and indicate that these scales can be helpful in predicting which workers are at risk of having future arm, shoulder and neck symptoms. The scales were constructed based on evidence from etiological studies several years ago. However, present results on the predictive validity of the questionnaire compare well with etiological findings in more recent systematic reviews on occupational risk factors for arm, shoulder and neck symptoms [3, 56, 63-65], which strengthens our results. It seems likely that arm, shoulder and neck symptoms are the result of many factors; including physical load and the psychosocial work environment and that these factors can reinforce each other [32, 33]. Several studies found that having had previous symptoms is a strong predictor of future symptoms and it can be concluded that musculoskeletal symptoms are persistent [29, 66-68]. Results in our study also indicate that current symptoms can be helpful in identifying

workers at risk of future arm, shoulder and neck symptoms. This information can subsequently be used to allocate tailored interventions, aimed at the prevention of symptoms in the future. The results indicate that the scales on information, work hours, and computer workstation physical attributes neither predicted arm, shoulder and neck symptoms at 6 months, nor at the other three longer time periods of 12, 18 or 24 months. The scale on furniture showed inconsistent results over the four time periods. When we combine these results with previous results on the internal consistency of the scales (Speklé et al. 2009), we find that all of these scales also scored poorly on internal consistency. The scale on work hours and the three scales on workplace ergonomics (work environment factors, furniture, and computer workstation physical attributes), all scored Cronbach's alpha between 0.30 and 0.45, whereas the other six scales scored 0.70 or higher. Since the scale on information consists of only one question, no Cronbach's alpha was calculated. We therefore suggest the removal of these three scales, which previously also have shown to have poor internal consistency, from the RSI QuickScan questionnaire. Even though the scale on information did not predict future symptoms arm, shoulder and neck symptoms, it does provide important information for organisations, since informing their employees on healthy computer use and the risks involved with computer work is a requirement by law in the Netherlands. Further research to determine the optimal cut-off points of each of the scales by calculating optimal sensitivity and specificity, would be useful. The goal of this study was to evaluate its usage and not its etiological strength. Nevertheless, the available data might be used for more etiological studies in the future.

An effective intervention must exist for screening to reduce exposure and/or prevalence of symptoms. Therefore, the programme must not only consist of a screening instrument with sound psychometric properties, but also offer effective interventions. In a related study on the effectiveness of a questionnaire based intervention programme on the prevalence of arm, shoulder and neck symptoms, risk factors and sick leave in computer workers, the effects of the RSI QuickScan intervention programme were small [21]. This may have been the result of difficulties with the implementation process of the proposed interventions. Some significant positive effects were found as to an increase in receiving education and a decrease in exposure to adverse postures and movements. With regard to symptoms and sick leave, only small and non-significant effects were found.

Recommendations for use of the RSI QuickScan

The RSI QuickScan questionnaire gives individual feedback to the respondents and advice on the specific actions that they can personally take in order to reduce their risk of arm, shoulder and neck symptoms. Furthermore, organisations are advised to undertake specific interventions. Ergonomic professionals use the RSI QuickScan as a primary prevention tool and integrate it in their periodical WHS, or use it as a secondary prevention tool in case of a high incidence or prevalence of arm, shoulder and neck symptoms

in a population of computer workers. When the instrument is used periodically, it is suggested to do so annually, if financial resources are available. The results from the effectiveness study [21] imply that the RSI QuickScan intervention programme can be used to increase the level of education and to decrease the exposure to adverse postures and movements. Although this study did not find evidence to support the claim that the RSI QuickScan intervention programme can be used to reduce symptoms or sick leave, it cannot be ruled out that the RSI QuickScan intervention programme could be effective, especially in the secondary prevention of arm, shoulder and neck symptoms, with a more successful implementation of the interventions. Therefore it is recommended that professionals in the field should pay close attention to the implementation of proposed interventions, since interventions will only be potentially effective if they are successfully implemented.

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Conclusion

In conclusion, the majority of the scales (work posture and movement, work tasks, job decision latitude, work relation with management and colleagues, work pace and load, recovery time, work environmental factors, eyesight and previous arm, shoulder and neck symptoms) in the RSI QuickScan questionnaire provides valid predictions of the risk of having future arm, shoulder and neck symptoms. However, the scale on work hours, and the one on computer workstation physical attributes did not predict arm, shoulder and neck symptoms at any of the investigated time lags. The scale on furniture showed inconsistent results. The RSI QuickScan questionnaire may be recommended as a tool in the identification of computer workers who should be targeted with interventions aimed at prevention of future symptoms.

References

[1] **Yoshioka E, Saijo Y, Fukui T, Kawaharada M, Kishi R.** *Association between duration of daily visual display terminal work and insomnia among local government clerks in Japan. American Journal of Industrial Medicine. 2008;51(2):148-56.*

[2] **Straker LM, Coleman J, Skoss R, Maslen BA, Burgess-Limerick R, Pollock CM.** *A comparison of posture and muscle activity during tablet computer, desktop computer and paper use by young children. Ergonomics. 2008;51(4):540-55.*

[3] **IJmker S, Huysmans MA, Blatter BM, Van der Beek AJ, Van Mechelen W, Bongers PM.** *Should office workers spend fewer hours at their computer? A systematic review of the literature. Occupational and Environmental Medicine. 2007;64(4):211-22.*

[4] **Palmer KT, Cooper C, Walker-Bone K, Syddall H, Coggon D.** *Use of keyboards and symptoms in the neck and arm: evidence from a national survey. Occupational Medicine (Lond). 2001;51(6):392-5.*

[5] **Punnett L, Bergqvist U.** *Visual Display Unit Work and Upper Extremity Musculoskeletal Disorders: A Review of Epidemiological Findings. Arbete och Hällsa. 1997;16:1-161.*

[6] **Robertson M, Amick III BC, DeRango K, Rooney T, Bazzani L, Harrist R, Moore A.** *The effects of an office ergonomics training and chair intervention on worker knowledge, behavior and musculoskeletal risk. Applied Ergonomics. 2009;40(1):124-35.*

[7] **Wahlstrom J.** *Ergonomics, musculoskeletal disorders and computer work. Occupational Medicine (Lond). 2005;55(3):168-76.*

[8] **Ekman A, Andersson A, Hagberg M, Hjelm EW.** *Gender Differences in Musculoskeletal Health of Computer and Mouse Users in the Swedish Workforce. Occupational Medicine. 2000;50(8):608-13.*

[9] **Brandt LP, Andersen JH, Lassen CF, Kryger A, Overgaard E, Vilstrup I, Mikkelsen S.** *Neck and shoulder symptoms and disorders among Danish computer workers. Scandinavian Journal of Work, Environment & Health. 2004;30(5):399-409.*

[10] **Woods V.** *Musculoskeletal disorders and visual strain in intensive data processing workers. Occupational Medicine (Lond). 2005;55(2):121-7.*

[11] **Rahman ZA, Atiya AS.** *Prevalence of Work-Related Upper Limbs Symptoms (WRULS) Among Office Workers. Asia-Pacific Journal of Public Health. 2009;21(3):252-8.*

[12] **Morken T, Riise T, Moen B, Bergum O, Vigeland Hauge SH, Holien S, Langedrag A, Olson HO, Pedersen S, Liahjell Saue IL, Midttun Seljebo G, Thoppil V.** *Frequent musculoskeletal symptoms and reduced health-related quality of life among industrial workers. Occupational Medicine (Lond). 2002;52(2):91-8.*

[13] **National Research Council IoM.** *Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities. Washington, D.C.: National Academy Press 2001.*

[14] **Blatter BM, Houtman I, Van den Bossche S, Kraan K, Van den Heuvel S.** *Gezondheidsschade en kosten als gevolg van RSI en psychosociale arbeidsbelasting in Nederland [Health damage and costs of RSI and psychosocial work load in the Netherlands]: Report on demand of The Dutch Ministry of Social Affairs and Employment. TNO Quality of Life; 2005.*

4

[15] **European Commission.** *First-phase consultation of the social partners on musculoskeletal disorders at work, available online at: http://ec.europa.eu/employment_ social/news/2004/nov/musculoskeletaldisorders_ en.pdf. Brussels; 2004.*

[16] **Bongers PM.** *The cost of shoulder pain at work. BMJ. 2001;322(7278):64-5.*

[17] **Melhorn JM.** *The Impact of Workplace Screening on the Occurrence of Cumulative Trauma Disorders and Workers' Compensation Claims. Journal of Occupational and Environmental Medicine. 1999;41(2):84-92.*

[18] **Melhorn JM.** *A Prospective Study for Upper-Extremity Cumulative Trauma Disorders of Workers in Aircraft Manufacturing. Journal of Occupational and Environmental Medicine. 1996;38(12):1264-71.*

[19] **Feuerstein M, Huang GD, Haufler AJ, Miller JK.** *Development of a Screen for Predicting Clinical Outcomes in Patients With Work-Related Upper Extremity Disorders. Journal of Occupational & Environmental Medicine. 2000;42(7):749-61.*

[20] **Dane D, Feuerstein M, Huang GD, Dimberg L, Ali D, Lincoln A.** *Measurement properties of a self-report index of ergonomic exposures for use in an office work environment. Journal of Occupational & Environmental Medicine. 2002;44(1):73-81.*

[21] **Speklé EM, Hoozemans MJM, Blatter BM, Heinrich J, Van der Beek AJ, Knol DL, Bongers PM, Van Dieën JH.** *Effectiveness of a questionnaire based intervention programme on the prevalence of arm, shoulder and neck symptoms, risk factors and sick leave in computer workers: A cluster randomised controlled trial in an occupational setting. BMC Musculoskeletal Disorders. 2010;11(1):99.*

[22] **Sluiter JK, De Croon EM, Meijman TF, Frings-Dresen MHW.** *Need for recovery from work related fatigue and its role in the development and prediction of subjective health complaints. Occupational and Environmental Medicine. 2003;60(suppl 1):i62-i70.*

[23] **Aarås A, Dainoff M, Ro O, Thoresen M.** *Can a More Neutral Position of the Forearm When Operating a Computer Mouse Reduce the Pain Level for Visual Display Unit Operators? A Prospective Epidemiological Intervention Study: Part II. International Journal of Human-Computer Interaction. 2001;13(1):13-40.*

[24] **Cook C, Burgess-Limerick R, Papalia S.** *The effect of upper extremity support on upper extremity posture and muscle activity during keyboard use. Applied Ergonomics. 2004;35(3):285-92.*

[25] **Harkness EF, Macfarlane GJ, Nahit ES, Silman AJ, McBeth J.** *Mechanical and psychosocial factors predict new onset shoulder pain: a prospective cohort study of newly employed workers. Occupational and Environmental Medicine. 2003;60(11):850-7.*

[26] **Toomingas A, Theorell T, Michelsen H, Nordemar R.** *Associations between self-rated psychosocial work conditions and musculoskeletal symptoms and signs. Scandinavian Journal of Work, Environment & Health. 1997;23(2):130-9.*

[27] **Houtman IL, Bongers PM, Smulders PG, Kompier MA.** *Psychosocial stressors at work and musculoskeletal problems. Scandinavian Journal of Work, Environment & Health. 1994;20(2):139-45.*

[28] **Hughes LE, Babski-Reeves K, Smith-Jackson T.** *Effects of psychosocial and individual factors on physiological risk factors for upper extremity musculoskeletal disorders while typing. Ergonomics. 2007;50(2):261-74.*

[29] Juul-Kristensen B, Sogaard K, Stroyer J, Jensen C*. Computer users' risk factors for developing shoulder, elbow and back symptoms. Scandinavian Journal of Work, Environment & Health. 2004;30:390-8.*

[30] Korhonen T, Ketola R, Toivonen R, Luukkonen R, Hakkanen M, Viikari-Juntura E. *Work related and individual predictors for incident neck pain among office employees working with video display units. Occupational and Environmental Medicine. 2003;60(7):475-82.*

[31] Aarås A, Horgen G, Bjørset H-H, Ro O, Thoresen M. *Musculoskeletal, visual and psychosocial stress in VDU operators before and after multidisciplinary ergonomic interventions. Applied Ergonomics. 1998;29(5):335-54.*

[32] Van der Windt DAWM, Thomas E, Pope DP, De Winter AF, Macfarlane GJ, Bouter LM, Silman AJ. *Occupational risk factors for shoulder pain: a systematic review. Occupational and Environmental Medicine. 2000;57(7):433-42.*

[33] Bongers PM, IJmker S, Van den Heuvel S, Blatter BM. *Epidemiology of work related neck and upper limb problems: Psychosocial and personal risk factors (Part I) and effective interventions from a bio behavioural perspective (Part II). Journal of Occupational Rehabilitation. 2006;16(3):272-95.*

[34] Punnett L, Gold J, Katz JN, Gore R, Wegman DH. *Ergonomic stressors and upper extremity musculoskeletal disorders in automobile manufacturing: a one year follow up study. Occupational and Environmental Medicine. 2004;61(8):668-74.*

[35] Ariëns GAM, Van Mechelen W, Bongers PM, Bouter LM, Van der Wal G. *Psychosocial risk factors for neck pain: A systematic review. American Journal of Industrial Medicine. 2001;39(2):180-93.*

[36] Gerr F, Marcus M, Monteilh C. *Epidemiology of musculoskeletal disorders among computer users: lesson learned from the role of posture and keyboard use. Journal of Electromyography & Kinesiology. 2004;14:25-31.*

[37] Leclerc A, Niedhammer I, Landre M-F, Ozguler A, Etore P, Pietri-Taleb F. *One-Year Predictive Factors for Various Aspects of Neck Disorders. Spine. 1999;24(14):1455.*

[38] Fredriksson K, Alfredsson L, Koster M, Thorbjornsson CB, Toomingas A, Torgen M, Kilbom A. *Risk factors for neck and upper limb disorders: results from 24 years of follow up [published erratum appears in Occupational and Environmental Medicine 1999;56(5):358]. Occupational and Environmental Medicine. 1999;56(1):59-66.*

[39] Cole DC, Hudak PL. *Prognosis of nonspecific work-related musculoskeletal disorders of the neck and upper extremity. American Journal of Industrial Medicine. 1996;29(6):657-68.*

[40] Speklé EM, Hoozemans MJM, Van der Beek AJ, Blatter BM, Bongers PM, Van Dieën JH. *Internal consistency, test-retest reliability and concurrent validity of a questionnaire on work-related exposure related to arm, shoulder and neck symptoms in computer workers. Ergonomics. 2009;52(9):1087-103.*

[41] Hakala PT, Rimpela AH, Saarni LA, Salminen JJ. *Frequent computer-related activities increase the risk of neck-shoulder and low back pain in adolescents. European Journal of Public Health. 2006;16(5):536-41.*

[42] Chang CH, Amick III BC, Menendez CC, Katz JN, Johnson PW, Robertson M, Dennerlein JT. *Daily computer usage correlated with undergraduate students' musculoskeletal symptoms. American Journal of Industrial Medicine. 2007;50(6):481-8.*

4

[43] **Jensen C, Finsen L, Søgaard K, Christensen H.** *Musculoskeletal symptoms and duration of computer and mouse use. International Journal of Industrial Ergonomics. 2002;30(4-5):265-75.*

[44] **Marcus M, Gerr F, Monteilh C, Ortiz DJ, Gentry E, Cohen S, Edwards A, Ensor C, Kleinbaum D.** *A prospective study of computer users: II. Postural risk factors for musculoskeletal symptoms and disorders. American Journal of Industrial Medicine. 2002;41(4):236-49.*

[45] **Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sorensen F, Andersson G, Jorgensen K. S***tandardised Nordic Questionnaires for the analysis of musculoskeletal symptoms. Applied Ergonomics. 1987;18:233-7.*

[46] **Sluiter JK, Rest KM, Frings-Dresen MHW.** *Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders. Scandinavian Journal of Work, Environment & Health. 2001;27:1-102.*

[47] **Zeger SL, Liang K-Y.** *Longitudinal Data Analysis for Discrete and Continuous Outcomes. Biometrics. 1986;42(1):121-30.*

[48] **Twisk JWR, Kemper HCG, Van Mechelen W.** *Tracking of activity and fitness and the relationship with cardiovascular disease risk factors. Medicine & Science in Sports & Exercise. 2000;32(8):1455-61.*

[49] **Ballinger GA.** *Using Generalized Estimating Equations for Longitudinal Data Analysis. Organizational Research Methods. 2004;7(2):127-50.*

[50] **Zeger SL, Liang K-Y, Albert PS.** *Models for Longitudinal Data: A Generalized Estimating Equation Approach. Biometrics. 1988;44(4):1049-60.*

[51] **Twisk JWR.** *Different Statistical Models to Analyze Epidemiological Observational Longitudinal Data: An Example from the Amsterdam Growth and Health Study. International Journal of Sports Medicine. 1997;18(S 3):S216-S24.*

[52] **Hoogendoorn WE, Bongers PM, De Vet HCW, Twisk JWR, Van Mechelen W, Bouter LM.** *Comparison of two different approaches for the analysis of data from a prospective cohort study: an application to work related risk factors for low back pain. Occupational and Environmental Medicine. 2002;59(7):459-65.*

[53] **SPSS.** *Statistical package for the social sciences [SPSS 16.0]. Chicago, IL 2007.*

[54] **Zorn CJW.** *Generalized Estimating Equation Models for Correlated Data: A Review with Applications. American Journal of Political Science. 2001;45(2):470-90.*

[55] **Twisk JWR, De Vente W.** *Attrition in longitudinal studies: How to deal with missing data. Journal of Clinical Epidemiology. 2002;55(4):329-37*

.
[56] **Waersted M, Hanvold T, Veiersted KB.** *Computer work and musculoskeletal disorders of the neck and upper extremity: A systematic review. BMC Musculoskeletal Disorders. 2010;11(1):79.*

[57] **Andersen JH, Harhoff M, Grimstrup S, Vilstrup I, Lassen CF, Brandt LPA, Kryger AI, Overgaard E, Hansen KD, Mikkelsen S.** *Computer mouse use predicts acute pain but not prolonged or chronic pain in the neck and shoulder. Occupational and Environmental Medicine. 2008;65(2):126-31.*

[58] **Bradburn NM, Mason WM.** *The effect of question order on responses. Journal of Marketing Research (pre-1986) 1964 57.*

[59] Dillman DA, Tortora RD, Bowker D. *Principles for constructing Web surveys. Washington State University, Social & Economic Sciences Research Center Web 1999.*

[60] Eisen EA. *Methodology for analyzing episodic events. Scandinavian Journal of Work, Environment & Health. 1999;25 Suppl 4:36–42.*

[61] Viikari-Juntura E, Takala E-P, Riihimäki H, Martikainen R, Jäppinen P. *Predictive validity of symptoms and signs in the neck and shoulders. Journal of Clinical Epidemiology. 2000;53(8):800-8.*

[62] Duncan PW, Wallace D, Lai SM, Johnson D, Embretson S, Laster LJ. *The Stroke Impact Scale Version 2.0 : Evaluation of Reliability, Validity, and Sensitivity to Change. Stroke. 1999;30(10):2131k-40.*

[63] Fagarasanu M, Kumar S. *Carpal tunnel syndrome due to keyboarding and mouse tasks: a review. International Journal of Industrial Ergonomics. 2003;31(2):119-36.*

[64] Hadler NM. *The semiotics of "upper limb musculoskeletal disorders in workers". Journal of Clinical Epidemiology. 2003;56(10):937-9.*

[65] Visser B, Van Dieën JH. *Pathophysiology of upper extremity muscle disorders. Journal of Electromyography and Kinesiology. 2006;16(1):1-16.*

[66] Descatha A, Chastang JF, Cyr D, Leclerc A, Roquelaure Y, Evanoff B. *Do workers with self-reported symptoms have an elevated risk of developing upper extremity musculoskeletal disorders three years later? Occupational and Environmental Medicine. 2008;65(3):205-7.*

[67] Nordlund A, Ekberg K. *Self reported musculoskeletal symptoms in the neck/shoulders and/or arms and general health (SF-36): eight year follow up of a case-control study. Occupational and Environmental Medicine. 2004;61(3):e11-e.*

[68] Silverstein BA, Viikari-Juntura E, Fan ZJ, Bonauto DK, Bao S, Smith C. *Natural course of nontraumatic rotator cuff tendinitis and shoulder symptoms in a working population. Scandinavian Journal of Work, Environment & Health. 2006;32(2):99-108.*

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CHAPTER **5** CHAPTER

Effectiveness of a questionnaire based intervention programme on the prevalence of arm, shoulder and neck symptoms, risk factors and sick leave in computer workers: A cluster randomised controlled trial in an occupational setting

Abstract

Introduction: Arm, shoulder and neck symptoms are very prevalent among computer workers. In an attempt to reduce these symptoms, a large occupational health service in the Netherlands developed a preventive programme on exposure to risk factors, prevalence of arm, shoulder and neck symptoms, and sick leave in computer workers. The purpose of this study was to assess the effectiveness of this intervention programme.

Methods: The study was a randomised controlled trial. The participants were assigned to either the intervention group or the usual care group by means of cluster randomisation. At baseline and after 12 months of follow-up, the participants completed the RSI Quick-Scan questionnaire on exposure to the risk factors and on the prevalence of arm, shoulder and neck symptoms. A tailor-made intervention programme was proposed to participants with a high risk profile at baseline. Examples of implemented interventions are an individual workstation check, a visit to the occupational health physician and an education programme on the prevention of arm, shoulder and neck symptoms. The primary outcome measure was the prevalence of arm, shoulder and neck symptoms. Secondary outcome measures were the scores on risk factors for arm, shoulder and neck symptoms and the number of days of sick leave. Sick leave data was obtained from the companies. Multilevel analyses were used to test the effectiveness.

Results: Of the 1,673 persons invited to participate in the study, 1,183 persons (71%) completed the baseline questionnaire and 741 persons participated at baseline as well as at 12-month follow-up. At 12-month follow-up, the intervention group showed a significant positive change (OR=0.48) in receiving information on healthy computer use, as well as a significant positive change regarding risk indicators for work posture and movement, compared to the usual care group. There were no significant differences in changes in the prevalence of arm, shoulder and neck symptoms or sick leave between the intervention and usual care group.

Conclusions: The effects of the RSI QuickScan intervention programme were small, possibly as a result of difficulties with the implementation process of the proposed interventions. However, some significant positive effects were found as to an increase in receiving education and a decrease in exposure to adverse postures and movements. With regard to symptoms and sick leave, only small and non-significant effects were found.

Trial registration: Netherlands National Trial Register NTR1117

Introduction

Arm, shoulder and neck symptoms, often referred to as RSI (Repetitive Strain Injury), are highly prevalent among computer workers [1]. A survey conducted amongst the working population in 15 European countries showed prevalences of 25% for neck/shoulder and arm pain, respectively [2]. A recent study amongst workers with these symptoms showed a symptom related decrease in the quality of life score of 31% [3]. To prevent symptoms, reduced performance and/or loss of production, employers implement interventions [4]. In the Netherlands, 61% of the organisations with more than 100 employees implemented such interventions [5]. Nevertheless, few randomised controlled trials, with sufficient size and statistical power, have been conducted [6] and, consequently, knowledge about the effectiveness of frequently used interventions is still lacking.

Various ergonomic, psychosocial and organisational risk factors for arm, shoulder and neck symptoms have been suggested [7] and the onset of such symptoms might be caused by a combination of these factors. However, intervention studies are often aimed at one specific work-related factor, such as the duration of computer work, or mouse use, the use of an adjustable chair, or at single work-related psychosocial factors, such as insufficient recovery time and insufficient social support [8-11]. Even though moderate evidence for some interventions was found, no strong evidence for the effectiveness of interventions in reducing symptoms in occupational settings could be established [8-11]. The fact that these interventions are usually aimed at the general population of computer workers and not at specific workers with a high exposure to certain factors, or that selected interventions did not address the most prominent risk factors might contribute to a limited effectiveness. Prevention efforts should ideally be targeted at specific populations with a high risk [12], as reducing a low exposure even further is unlikely to yield much effect. To improve the effectiveness of interventions aimed at reducing the prevalence of arm, shoulder and neck symptoms, exposure to risk factors, and sick leave in computer workers, a multidimensional intervention programme was developed. This intervention program is quite unique in that it incorporates many different aspects, addressing a broad spectrum of potential risk factors. Instead of using generic strategies, which is common among occupational health services in the Netherlands, this method establishes a risk profile of the target population and subsequently advises interventions following a deci-sion tree based on that risk profile.

The objective of this study was to assess the effectiveness of this intervention programme on the prevalence of arm, shoulder and neck symptoms, reduction of expo-sure to risk factors, and sick leave in a population of computer workers.

5

Methods

Design and study population

The study was designed as a cluster Randomised Controlled Trial (RCT) with an intervention group and a usual care group. Participants were recruited from January 2005 to January 2006. The participating organizations were approached through the occupational health service and selected by willingness to participate. All workers of participating organisational units were invited to participate by e-mail. Measurements took place at baseline, after 6-months and after 12-months. The source population consisted of computer workers from 7 Dutch organisations in various branches (e.g. health care, local government, nature conservation, engineering, education and regulatory affairs), located throughout the Netherlands. The population consisted of office staff, local government officials, engineers, consultants, teachers, health care personnel, nature conservation professionals, researchers and managers. Figure 1 shows the CONSORT [13] diagram of the flow of clusters and participants through the phases of the trial. Of the 1,673 persons who were invited to participate in the study, 1,183 persons (71%) completed the baseline questionnaire. A total of 741 persons participated at baseline as well as at 12-months follow-up and were included in the analyses. Units that discontinued the intervention, did receive full feedback on their questionnaire results, but declined other proposed interventions as a result of financial constraints. Prior to inclusion, all participating organisations expressed their willingness to take preventive measures in case the results of the investigation would give cause to this. Employees were given time during work to fill out the questionnaires and participate in the interventions. Workers with and without arm, shoulder and neck symptoms were included. Workers had to be able to read Dutch, such that they could understand the information provided and complete the questionnaire.

The study design, protocols, procedures and informed consent form were approved by the Ethics Committee of the Faculty of Human Movements Sciences of the VU University Amsterdam, and all participants electronically provided informed consent before filling out the baseline questionnaire.

Randomisation

The participants were assigned to either intervention group or usual care group by means of cluster randomisation. To prevent unbalanced randomisation, workers were pre-stratified by the HRM departments of the participating organisations, who formed clusters of approximately the same size and with a comparable amount of computer work. Teams or departments were left intact, to avoid crossover effects and to enhance the compliance in the intervention group. In some cases, clusters consisted of participants in the same building or floors of a building. Allocation concealment was performed by

using sealed envelopes containing the names of the clusters in each organisation. The envelopes were then randomly divided into an intervention and usual care groups by the HRM department. Even though participants were not informed about their allocation, workers could not be blinded for the intervention due to the character of the interventions. The principal investigator was not blinded for group allocation when performing the data analysis.
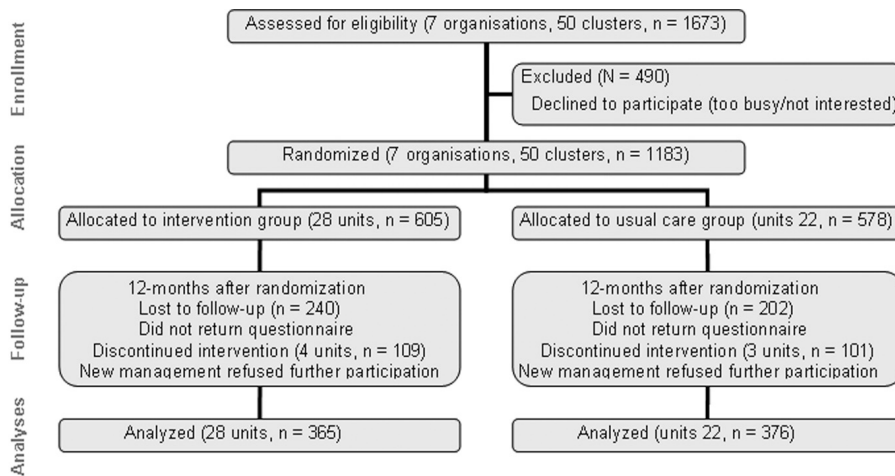
Figure 1. *Flow of clusters and participants through the phases of the trial.*
Units that discontinued the intervention, did receive full feedback on their RSI QuickScan questionnaire results, but declined other proposed interventions as a result of financial constraints.

Data collection

At baseline and 6 and 12 months follow-up, the workers completed the internet-based RSI QuickScan questionnaire on exposure to risk factors and the 6-months and 7-days prevalence of arm, shoulder and neck symptoms. The psychometric properties of this measurement tool have previously been tested and results indicate an acceptable reliability, concurrent validity and homogeneity [7]. All participants received an e-mail in which: 1) the goal of the investigation was explained, 2) information was provided on protection of confidentiality and 3) individual login information was presented. A letter with information about the study was attached to this e-mail. An incentive was allotted amongst workers who participated in all measurements for each organisation. A description of the content of the questionnaire can be found at additional file 1: Questionnaire *[http://www.rsiquickscan.com/research/questionnaire.pdf]*.

Participants who had not logged in to the RSI QuickScan and those who did log in but did not complete the questionnaire received a reminder to complete the questionnaire two weeks after the first e-mail and again one week thereafter. One week after the final reminder (one month after the initial e-mail was send) access to the online questionnaire was closed.

Intervention group

The intervention group received full feedback on their RSI QuickScan questionnaire results. This feedback was given after completing each section of the questionnaire and consisted of scores on a scale from 1 to 10, a visual representation of the score with a graph, an interpretation of the score and an elaborate advice on the specific actions that they could personally take in order to reduce their risk of arm, shoulder and neck symptoms (Figure 2). If workers reported severe symptoms in the arm, shoulder and neck region, their occupational physician invited them for a consultation. Furthermore, from the information given by the respondents, a risk profile was made, using the traffic light coding system, also known as the RAG rating [14]. A score of 30% or less of the maximum on a scale was classified as a low risk, colour coded 'green'. A score of 31% to 60% of the maximum on a scale was classified as a medium risk, colour coded 'amber'. A score of 61% or more of the maximum on a scale was classified as a high risk, colour coded 'red'. All scales combined in a graph illustrate the risk profile of an individual or a group. This graph was provided not only for the individual, but also for the organisation, the department or function group (Figure 3). If more than 30% of the participants had a red score or more than 60% of the participants had a red or amber score, a tailor-made intervention programme was proposed. Per scale a (set of) intervention(s) to be advised to the participating organisations was pre-defined.
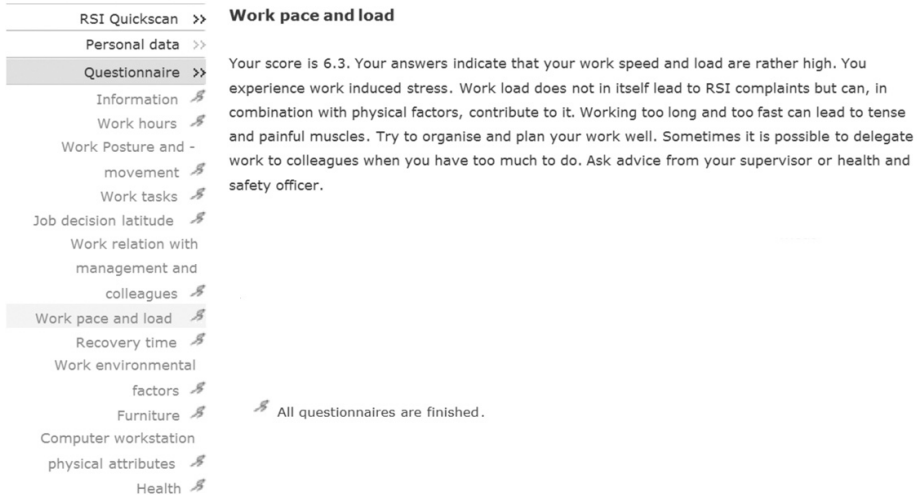
Figure 2. *An example of the individual feedback on the RSI QuickScan questionnaire results.*

The interventions were aimed at each of the factors in the RSI QuickScan, with a total of 16 interventions aimed at reducing the associated risk. Examples of proposed interventions are:

Individual level

- Individual workstation check - An advisor visits the worker at his/her work station and advises on ergonomic aspects, such as the set-up of the workstation and the furniture.
- Eyesight check – In order to determine whether there is a need for computer glasses.
- A visit to the occupational health physician.

Group level

- Education programme on the prevention of arm, shoulder and neck symptoms for employees - This involves education about arm, shoulder and neck symptoms, the ergonomic aspects of the workstation and the effects of work organisational factors.
- Handling stress in the workplace - A training aimed at getting insight into stress and stress situations, to improve coping, learn relaxation techniques and influence one's own work situation.

To give the organisations a choice in intensity and costs of interventions, multiple interventions were available, differing mainly in duration, ranging from a two-hour information session to a training consisting of eight half-day sessions. Interventions were

carried out both on an individual and a group level. Depending on their risk profile, some workers were offered multiple interventions. The organisations are responsible for carrying out the program. However, the quality control of interventions lies with the Occupational Health Service, whose quality is certified by the Ministry of Social Affairs and Employment, and the professionals who work for it. A description of all interventions can be found at additional file 2: Interventions *[http://www.rsiquickscan.com/ research/interventions.pdf]*. There were no harmful effects of the interventions observed for the individuals during the study.

Usual care group

In contrast to the intervention group, the usual care group did not receive elaborate advice on the actions that they could personally take after completing the RSI QuickScan, but more general and limited advice. Furthermore, they did not receive interventions based on the risk profile during the time of the study. However, because of ethical considerations, workers, who reported severe symptoms in the arm, shoulder and neck region were also invited by their occupational physician for a consultation, even though they were part of the usual care group. These workers were treated according to the Dutch guideline on arm, shoulder and neck symptoms [15], which states that workers should try to continue their work, except for tasks that induce severe pain. Furthermore, they received advice on possible treatments, adjustments in the workplace and could be referred to a physical therapist. For other actions the usual care group was put on a waiting list, so that they received interventions that were similar to those in the intervention group, but only after the study was ended.

Outcome measures

The primary outcome measure was the prevalence of arm, shoulder and neck symptoms. Secondary outcome measures were the scores on risk factors for arm, shoulder and neck symptoms and the number of days of sick leave.

To assess exposure to potential risk factors for the establishment of risk profiles related to arm, shoulder and neck symptoms in computer workers we used a questionnaire, consisting of items on work (e.g. work hours, work tasks), relation with management and colleagues, office ergonomics (e.g. furniture and computer workstation physical attributes) and health (e.g. arm, shoulder and neck symptoms). In total, the questionnaire consisted of 95 items. Reliability and concurrent validity were shown to be satisfactory [7]

The prevalence of arm, shoulder and neck symptoms was estimated with the questionnaire, which used a slightly altered version of the Nordic Questionnaire by Kuorinka et al. [16]. It specifies 7 areas in the arm, shoulder and neck region, as suggested by Sluiter et al. [17]. Furthermore, the questionnaire did not only show a dorsal view of the arm,

shoulder and neck region, but also a frontal view. The Nordic Questionnaire has been extensively tested for validity [16].
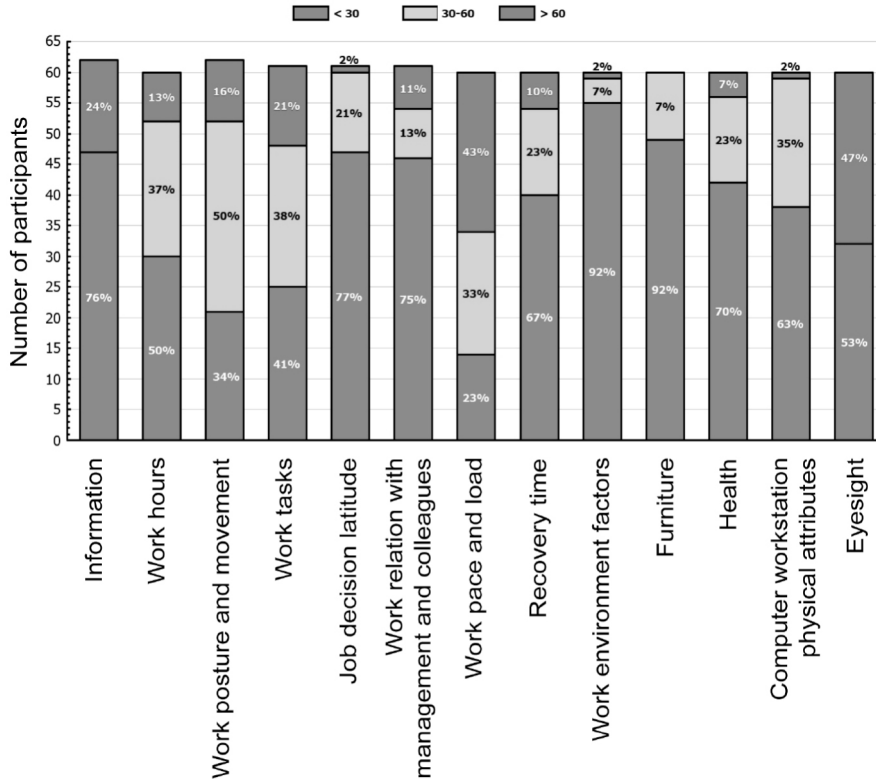
Figure 3. *An example of the feedback on the RSI QuickScan questionnaire results of a group.*

The prevalence of arm, shoulder and neck symptoms was defined as: regular or long-lasting symptoms in one or more regions of arm, shoulder and neck, in the past six months and/or in the past seven-days. A description of these questions can be found at additional file 1: Questionnaire [http://www.rsiquickscan.com/research/questionnaire. pdf]. The overall prevalence of arm, shoulder and neck symptoms was divided into two subgroups: proximal (neck, upper-back and shoulders) and distal (elbows, forearms, wrists and hands) symptoms. The total symptom score consisted of the sum of points scored on the scales arm, shoulder and neck symptoms. Information on the number of days of sick leave was obtained from the HRM departments of the participating organisa-tions. The data consisted of total sick leave, maternity leave excluded, and not solely sick leave due to (serious) arm, shoulder and neck symptoms.

Statistical analysis

In the sample size calculation, an intracluster correlation of 0.05 was assumed, an average of 15 workers per cluster, an initial participation of 70%, and a loss to follow-up of 40%. Under these assumptions, we anticipated to be able to detect a difference of 15% (35% versus 50%) in the prevalence of symptoms between the intervention and usual care group (power of 80%; one-sided significance level, 0.05) with 225 workers with completed questionnaires in 25 clusters assigned to both the intervention and control group [18].

Only workers who filled out the baseline questionnaire and the 12-months follow-up questionnaire were included in the analyses. Data of the 6-months follow-up were not analyzed, as only few interventions were implemented prior to this measurement. Analyses to estimate the effect of the intervention were pre-specified and done according to the intention-to-treat principle [19].

Multilevel analyses were used to investigate the differences in changes in outcome variables regarding prevalence of arm, shoulder and neck symptoms, risk factors, and sick leave between the intervention group and the usual care group after 12 months of follow-up. In the regression model the values of the outcome variables, either continuous or dichotomous, at 12-months follow-up were considered as dependent variables. The intervention level (yes/no) and the baseline values of the outcome variables were considered as independent variables, so that scores at 12 months follow-up were corrected for baseline. For the dichotomous outcome variables, i.e., information, eyesight, prevalence of (overall, proximal and distal) arm, shoulder and neck symptoms, logistic multilevel regression analysis were used. No other corrections were performed.

Multilevel analyses were used in order to adjust for possible dependence between observations from the same organisation or department. The data of this study were clustered at three levels: company, department, and individual. All multilevel statistical analyses were performed using MLwiN version 2.02 [20]. All non-multilevel statistical analyses were performed using SPSS version 16 [21].

Results

Randomisation

There were no significant differences regarding age, gender, working more than 30 hours per week, and working more than 4 hours with the computer per day, between the intervention and usual care groups (Table 1). However, there were significant differences between the two groups in the number of sick leave days in the six months prior to baseline, with the usual care group reporting more sick leave days.

Table 1. *Baseline characteristics of the study population.*

	Usual care (N=578)	Intervention (N=605)
Gender (male)	334 (57.8%)	378 (62.5%)
Age (years) (mean, SD)	43.8 (9.7))	44.4 (9.2
Work more than 30 hours per week	445 (76.9%)	452 (74.6%)
Work more than 4 hours per day with the computer	406 (70.3%)	430 (70.0%)
Number of sick leave days in the 6-months period prior to baseline (median)	1.0	0.0
- % workers with 0 days sick leave	49	50
- % workers with 1 – 7 days sick leave	27	30
- % workers with 7 – 21 days sick leave	15	14
- % workers with > 21 days sick leave	9	6

Values are numbers (percentages) unless stated otherwise. SD = standard deviation.

Non-response analysis

Respondents and non-respondents were similar in age, but there were significantly fewer men in the respondent category. Non-respondents at follow-up had significantly higher risk scores on the scales 'information', 'work posture and movement', and 'furniture'. Non-respondents had a lower prevalence of distal symptoms, but a significantly higher number of sick leave days in the 6-months period prior to baseline.

Utilization rate interventions

Of the 16 possible interventions 6 were implemented (utilization rate in the intervention / usual care group % yes): Occupational health physician (8 / 6), Education on the prevention of RSI for employees (26 / 0), RSI and stress (24 / 2), Eyesight check (19 / 7), Individual workstation check (2 / 1), Task analyses (1 / 0).

Effect of the intervention programme

Table 2 gives an overview of the risk factors, prevalence of arm, shoulder and neck symptoms and sick leave at baseline and 12 months of follow-up. After 12-months of follow-up, the intervention group scored significantly better than the usual care group on the scales 'Information' and 'Work posture and movement' (Table 3). Corrected for baseline values, a significant Odds Ratio of 0.48 (95% CI: 0.28 to 0.82) was found for information, indicating that at follow-up the participants in the intervention group had a two times higher chance to have had information concerning prevention than the usual care group. For the scale work posture and movement, the significant regression coefficient of -0.35 (95% CI: 0.68 to -0.03) indicates that the intervention group had at follow-up on average 0.35 points less on a 0 to 11 points scale than the usual care group, indicating a slightly lower risk. The results were corrected for baseline values. There was a slight reduction in scores for several other factors, but this occurred in both, the intervention and usual care, groups. There were no significant differences in the changes in prevalence of arm, shoulder and neck symptoms between the intervention and usual care group. The overall prevalence of arm, shoulder and neck symptoms decreased by 9% in both the intervention (decrease from 51% to 42%) and usual care group (decrease from 56% to 47%). There were no significant differences in changes in sick leave between the intervention and usual care group. Compliance of the participants varied from 51%, for an eyesight check, to 89% for a visit to the occupational health physician. Low compliance was sometimes caused by the decision of participating organisations not to accept (parts of) the proposed intervention plan. In two of the participating organisations new management decided not to implement any of the proposed interventions.

Table 2. *Risk factors, prevalence of arm, shoulder and neck symptoms and sick leave at baseline and 12 months of follow-up.*

	Usual care		Intervention	
Risk factors	**Baseline**	**12-month**	**Baseline**	**12-month**
Information (range 0-1) (% workers without training)	40	25	41	17
Work hours (median; range 0-12) (% workers with a red / amber score)	4.0 (52.3%) 11 /30	4.0 (51.3%) 8 / 31	4.0(51.5%) 11 / 29	4.0 (50.8%) 8 / 30
Work posture and movement (median; range 0-11) (% workers with a red / amber score	4.0 (62.5%) 13 / 40	3.0 9 / 26	4.0 (64.4%) 11 / 41	2.0 5 / 28
Work tasks (median; range 0-5) (% workers with a red / amber score	1.0 (53.3%) 15 / 31	1.0 (58.2%) 11 / 30	1.0 (53.8%) 14 / 32	1.0 (60.7%) 12 / 27
Job decision latitude (median; range 0-9) (% workers with a red / amber score	0.0 (52.7%) 2 / 15	0.0 (56.8%) 2 / 13	0.0 (55.1%) 3 / 11	0.0 (57.9%) 3 / 10
Work relation with management and colleagues (median: range 0-7) (% workers with a red / amber score	1.0 (65.5%) 7 / 17	1.0 (62.2%) 9 / 15	1.0 (59.0%) 8 / 18	1.0 (60.9%) 13 / 15
Work pace and load (median; range 0-8) (% workers with a red / amber score	4.0 37 / 26	3.0 (52.4%) 34 / 28	3.0 34 / 31	3.0 (54.3%) 34 / 28
Recovery time (median; range 0-6) (% workers with a red / amber score	1.0 (74.3% 6 / 19	0.0 6 / 18	1.0 (75.0%) 6 / 19	1.0 7 / 18
Work environmental factors (median; range 0-4) (% workers with a red / amber score	1.0 (76.4%) 7 / 17	1.0 (77.8%) 7 / 15	1.0 (76.4%) 5 / 19	1.0 (81.2%) 4 / 14
Furniture (median; range 0-10) (% workers with a red / amber score	2.0 (63.1%) 5 / 32	1.0 1 / 25	2.0 (66.4%) 4 / 30	2.0 3 / 28
Computer workstation physical attributes (median; range 0-7) (% workers with a red / amber score	1.0 (49.3%) 2 / 22	1.0 (63.5%) 0 / 14	1.0 (51.3%) 3 / 21	1.0 (66.9%) 1 / 11
Eyesight (range 0-1) (% workers with problems; range 0-1)	34	29	37	29
Arm, shoulder and neck symptoms				
Prevalence symptoms (%)	56	47	51	42
Prevalence proximal symptoms (%)	46	38	39	31
Prevalence distal symptoms (%)	28	24	31	24
Total symptom score (median; range 0-44) (% workers with a red / amber score)	7.0 12 / 24	6.0 9 / 19	7.0 9 / 21	6.0 4 / 20
Sick leave Number of sick leave days (median) - % workers with 0 days sick leave - % workers with 1 – 7 days sick leave - % workers with 7 – 21 days sick leave - % workers with > 21 days sick leave	1.0 (52.2%) 49 27 15 9	1.0 (51.7%) 45 31 15 9	0.0 (50.2%) 50 30 14 6	0.0 (50.9%) 51 29 12 8

Values indicate the mean except where otherwise indicated. Where applicable, scale extremes are given in the left-hand column. High scores reflect a high risk. (%) = cumulative percent at median value.

Table 3. *Results of longitudinal multilevel analyses.*

	Intervention effect β/Odds (95% C.I.)	
	β	Odds
Risk factors		
Information	.	0.48 (0.28; 0.82)
Work hours (range 0-12)	-0.08 (-0.33; 0.17)	.
Work posture and movement (range 0-11)	-0.35 (-0.68; -0.03)	.
Work tasks (range 0-5)	-0.04 (-0.24; 0.17)	.
Job decision latitude (range 0-9)	-0.10 (-0.35; 0.15)	.
Work relation with management and colleagues (range 0-7)	0.02 (-0.34; 0.38)	.
Work pace and load (range 0-8)	-0.00 (-0.31; 0.30)	.
Recovery time (range 0-6)	0.05 (-0.16; 0.25)	.
Work environmental factors (range 0-4)	-0.09 (-0.24; 0.07)	.
Furniture (range 0-10)	0.24 (-0.12; 0.61)	.
Computer workstation physical attributes (range 0-7)	-0.09 (-0.29; 0.10)	.
Eyesight	.	0.88 (0.62; 1.27)
Arm. shoulder and neck symptoms		
Prevalence arm, shoulder and neck symptoms	.	0.89 (0.61; 1.30)
Prevalence proximal symptoms	.	0.78 (0.54; 1.12)
Prevalence distal symptoms	.	0.90 (0.49; 1.67)
RSI score (range 0-44)	-0.75 (-1.78; 0.29)	.
Sick leave		
Days of sick leave	-0.27 (-2.85; 2.31)	.

β, regression coefficient; 95% C.I., 95% confidence interval.

The results show the differences in changes in outcome variables regarding risk factors, the prevalence of arm, shoulder and neck symptoms and the amount of sick leave between the intervention group and the usual care group after 12 months of follow-up. The results were corrected for baseline. β represents the difference in score for the range indicated in the table.

Discussion

The overall effects of the RSI QuickScan intervention programme were small. The overall prevalence of arm, shoulder and neck symptoms decreased by 9% in both the intervention and usual care group, but no significant differences between groups was found. The positive findings of this study were a significant improvement of the intervention group on the scales 'Information' and 'Work posture and movement' after 12 months. There were no significant differences in sick leave between the intervention and usual care groups.

Comparison with other studies

These findings regarding the effectiveness of this intervention programme on the reduction of prevalence of arm, shoulder, neck symptoms, exposure to risk factors, and sick leave in computer workers, partially confirm those of previous studies, where also small effects were found. Several studies on the effectiveness of preventative interventions have been published in the last decade. A systematic review by Brewer et al. [9] found moderate evidence for no effect of workstation adjustments and also no effect of rest breaks together with exercise during the breaks. However, the review did find a positive effect of alternative pointing devices on musculoskeletal outcomes. A review by Boocock et al. [8] identified no single-dimensional or multi-dimensional strategy for intervention that was considered effective across occupational settings. It is important to note that no study comparable to the RSI QuickScan intervention programme, where the advised set of interventions is based on a previously established risk profile, was found in the literature.

Implementation of the interventions

The limited effect of the RSI QuickScan intervention programme might be caused by problems with regard to the implementation of the interventions. The interventions were sold at their normal commercial price and even though all participating organisations prior to inclusion had stated that they were prepared to invest in the necessary preventive measures, in practice some of the participating organisations chose not to do so, due to a low degree of support from the management and/or lack of financial resources. Consequently, workers who should have participated in an intervention were never offered one, let alone participated in one. The intention was to start the interventions that were accepted within a three month period after the first measurement was finished. In practice, some of the interventions started after 6-months, leaving little time for effects on the arm, shoulder and neck symptoms or sick leave.

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Effectiveness of the interventions

Exposure to most risk factors and prevalence of arm, shoulder and neck symptoms decreased in both groups. The information on risk factors provided in the questionnaire and the feedback seems to have led to more favourable behaviour and therefore, a decrease in risk factors. Furthermore, the focus on arm, shoulder and neck symptoms in the participating companies may also have caused greater awareness of the risks attributed to computer use and may have contributed to the overall decline of risk factors and arm, shoulder and neck symptoms. These positive effects in both the intervention and the control group may have made it more difficult to achieve results op top of this, which would make it harder to detect significant differences between the intervention and usual care group. The questionnaire contains questions about the duration and location of the symptoms, but it does not ask questions about the pain intensity and function, which might make it more difficult to find an effect.

The usual care group had an overall higher prevalence of arm, shoulder and neck symptoms compared to the intervention group and the symptoms in the usual care group were more serious. This makes a regression to the mean likely to occur.

The data we obtained from the HRM department consisted of total sick leave and not solely sick leave due to (serious) arm, shoulder and neck symptoms. Since the average number of sick leave days at baseline was already relatively low and considering that sick leave due to arm, shoulder and neck symptoms was even smaller, the probability to find a significant decrease was low.

Even though arm, shoulder and neck symptoms are highly prevalent among computer workers, it remains to be seen if long-lasting pain is related to elements of computer use. [22, 23]. This might be another reason for the negative findings in this study.

Strengths and limitations of the study

Strengths of this study are its solid RCT design, combined with cluster randomisation to minimize contamination between the two groups and to increase compliance with the interventions. Comparability between the groups was good. The intervention took place during a full year eliminating possible seasonal variance, which could have biased the results. Furthermore, the size of the research population in the present study provided sufficient statistical power. Generalisation of the results to other computer workers is enhanced by the fact that the research population consisted of computer workers from all over the Netherlands, employed in different settings (e.g. health care, local government, engineering, education) and a broad range of jobs. The age and gender distributions corresponded with the distribution in the working population in the Netherlands.

There are also some limitations within this study. Since the respondents, in comparison to the non-respondents at baseline, had received more information, a better work posture and better furniture, there was less room for improvement in these areas, which might

have had a negative effect on the results. Also the fact that they had a significantly lower number of sick leave days in the 6-months period previous to baseline makes it more difficult to get positive results.

The test-retest validity, concurrent validity and homogeneity of the RSI QuickScan have been studied and the RSI QuickScan has proven to be a valid instrument to assess risk factor and arm, shoulder and neck symptoms. However, the reliability of self-reported duration of computer use and postural load, by means of questionnaires, has been questioned [24-28]. Furthermore, there is still uncertainty about risk factors and hence, the predictive validity of the RSI QuickScan is unsure.

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Conclusions

In conclusion, the positive effects of the RSI QuickScan intervention programme are limited to a reduction of exposure to only some risk factors. No significant effects were found for most risk factors, for arm, shoulder and neck symptoms and sick leave. This might be caused by the fact that the population consisted of computer workers with- and without symptoms, and by workers not receiving the advised intervention. For those who did receive an intervention, the duration and intensity of the interventions was often low. Given the still high percentage of workers suffering from arm, shoulder and neck symptoms, further studies on the effect of interventions in reducing arm, shoulder and neck symptoms in occupational settings are recommended.

Acknowledgements

References

1] **Wahlstrom J.** *Ergonomics, musculoskeletal disorders and computer work. Occupational Medicine (Lond). 2005;55(3):168-76.*

[2] **De Kraker H, Blatter BM.** *Prevalentiecijfers van RSI-klachten en het voorkomen van risicofactoren in 15 Europese landen. (Prevalence of RSI-complaints and the occurrence of risk factors in 15 European countries). Tijdschrift voor Gezondheidswetenschappen. 2005;83:8-15.*

[3] **Sluiter JK, Frings-Dresen MHW.** *Quality of life and illness perception in working and sick-listed chronic RSI patients. International Archives of Occupational and Environmental Health. 2008;81(4):495-501.*

[4] **Heinrich J, Blatter BM, Van den Bossche SNJ.** *RSI-maatregelen in de Nederlandse beroepsbevolking. Tijdschrift voor Bedrijfs- en Verzekeringsgeneeskunde. 2005(13):69-75.*

[5] **Marketconcern.** *Arbodienstenmonitor 2008. Bunnik; 2008.*

[6] **Bongers PM.** *Why is the information on cost effectiveness of interventions to manage neck and upper limb symptoms still lacking, while all stakeholders would benefit from this information? Occupational and Environmental Medicine. 2007;64(5):289-90.*

[7] **Speklé EM, Hoozemans MJM, Van der Beek AJ, Blatter BM, Bongers PM, Van Dieën JH.** *Internal consistency, test-retest reliability and concurrent validity of a questionnaire on work-related exposure related to arm, shoulder and neck symptoms in computer workers. Ergonomics. 2009;52(9):1087-103.*

[8] **Boocock MG, McNair PJ, Larmer PJ, Armstrong B, Collier J, Simmonds M, Garrett N.** *Interventions for the prevention and management of neck/upper extremity musculoskeletal conditions: a systematic review. Occupational and Environmental Medicine. 2007;64:291-303.*

[9] **Brewer S, Van Eerd D, Amick III BC, Irvin E, Daum KM, Gerr F, Moore JS, Cullen K, Rempel D.** *Workplace interventions to prevent musculoskeletal and visual symptoms and disorders among computer users: a systematic review. Journal of Occupational Rehabilitation. 2006;16:325-58.*

[10] **Verhagen AP, Karels C, Bierma-Zeinstra SMA, Feleus A, Dahaghin S, Burdorf A, Koes BW.** *Exercise proves effective in a systematic review of work-related complaints of the arm, neck, or shoulder. Journal of Clinical Epidemiology. 2007;60(2):110.e1-.e14.*

[11] **Blatter BM, Bongers PM, Van Dieën JH, Van Kempen PM, De Kraker H, Miedema H, Reijneveld CN, De Vet HCW.** *RSI measures: prevention, treatment and return to work. [RSI-maatregelen: preventie, behandeling en reïntegratie]. The Hague: Ministry of Social Affairs and Employment; 2004.*

[12] **Staal JB, de Bie RA, Hendriks EJM.** *Aetiology and management of work-related upper extremity disorders. Best Practice & Research Clinical Rheumatology. 2007;21(1):123-33.*

[13] **Campbell MK, Elbourne DR, Altman DG.** *CONSORT statement: extension to cluster randomised trials. BMJ. 2004;328(7441):702-8.*

[14] **Pitcher T.** *The sea ahead: challenges to marine biology from seafood sustainability. Hydrobiologia. 2008;606(1):161-85.*

[15] **Verbeek JHAM, Broekkamp CW, Cuilenburg LC, Van Heijst AJP, Kramer E, Kremer EAJM, Rutten RGHM, Tellekamp JJ, Verhoeven ACLPJ.** *Handelen van de bedrijfsarts bij werknemers met klachten aan arm, schouder of nek. Amsterdam: NVAB 2003.*

5

[16] **Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sorensen F, Andersson G, Jorgensen K.** *Standardised Nordic Questionnaires for the analysis of musculoskeletal symptoms. Applied Ergonomics. 1987;18:233-7.*

[17] **Sluiter JK, Rest KM, Frings-Dresen MHW.** *Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders. Scandinavian Journal of Work, Environment & Health. 2001;27:1-102.*

[18] **Hayes RJ, Bennett S.** *Simple sample size calculation for cluster-randomized trials. International Journal of Epidemiology. 1999;28(2):319-26.*

[19] **Hollis S, Campbell F.** *What is meant by intention to treat analysis? Survey of published randomised controlled trials. BMJ. 1999;319(7211):670-4.*

[20] **Rasbash J, Browne W, Healy M, Cameron B, Charlton C.** *MLwiN. In: Centre for Multilevel Modelling IoE, ed. 2.02 ed. London 2005.*

[21] **SPSS.** *Statistical package for the social sciences [SPSS 16.0]. Chicago, IL 2007.*

[22] **Andersen JH, Harhoff M, Grimstrup S, Vilstrup I, Lassen CF, Brandt LPA, Kryger AI, Overgaard E, Hansen KD, Mikkelsen S.** *Computer mouse use predicts acute pain but not prolonged or chronic pain in the neck and shoulder. Occupational and Environmental Medicine. 2008;65(2):126-31.*

[23] **IJmker S, Huysmans MA, Blatter BM, Van der Beek AJ, Van Mechelen W, Bongers PM.** *Should office workers spend fewer hours at their computer? A systematic review of the literature. Occupational and Environmental Medicine. 2007;64(4):211-22.*

[24] **Heinrich J, Blatter BM, Bongers PM.** *A comparison of methods for the assessment of postural load and duration of computer use. Occupational and Environmental Medicine. 2004;61(12):1027-31.*

[25] **Homan MM, Armstrong TJ.** *Evaluation of Three Methodologies for Assessing Work Activity During Computer Use. Journal of Occupational and Environmental Hygiene. 2003;64(1):48-55.*

[26] **Lassen CF, Mikkelsen S, Kryger AI, Andersen JH.** *Risk factors for persistent elbow, forearm and hand pain among computer workers. Scandinavian Journal of Work, Health & Environment. 2005;31(2):122-31.*

[27] **Richter JM, Slijper HP, Over EAB, Frens MA.** *Computer work duration and its dependence on the used pause definition. Applied Ergonomics. 2008;39(6):772-8.*

[28] **IJmker S, Leijssen J, Blatter BM, Van der Beek AJ, Van Mechelen W, Bongers PM.** *Test-retest reliability and validity of self-reported duration of computer use at work. Scandinavian Journal of Work, Environment & Health. 2008;34(2):113-9.*

Additional files

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Additional file 1. Overview of the content (main areas, scales and questions) of the internet-based questionnaire RSI QuickScan for the assessment of risk factors [*http://www.rsiquickscan.com/research/questionnaire.pdf*]

Main areas	Scales and questions
Work	**Information**
	1. Information on computer work and health
	Work hours
	2. Amount of work hours per week
	3. Amount of work days per week
	4. Hours computer work per day
	5. Hours private computer use per day
	6. Amount of breaks per day
	7. Total break time per day
	Work posture and movement
	8. Upper body slightly bent forward
	9. Upper body bent forward a lot
	10. Trunk slightly twisted
	11. Trunk twisted a lot
	12. Upper body bent forward and twisted
	13. Neck hunched forward
	14. Neck hunched backward
	15. Neck twisted
	16. Wrist bent
	17. Wrist extended
	18. Wrist twisted
	Work tasks
	19. Repetitive movements arm. Hand fingers
	20. Repetitive twisting/bending upper body
	21. Repetitive twisting/bending upper body
	22. Same work all day
	23. Same work every day
	24. Repetitive movements
	Job decision latitude
	25. Choose time begin/stop work
	26. Choose time breaks
	27. Choose which days off
	28. Choose how to do your work
	29. Choose order of work tasks
	30. Choose when work tasks
	31. Leave workspace
	32. Choose stop work
	33. Control work pace

(continued)

Additional file 1. *(continued)*

Main areas	Scales and questions
	Work relation with management and colleagues
	34. Good management
	35. Irritated by others
	36. Management notes what you say
	37. Good general atmosphere
	38. Management knows you / your work
	39. Support direct supervisor
	40. Support colleague
	41. Sufficient information from company
Work	**Work pace and load**
	42. Pace of work / work load regularly high
	43. Regularly work under time pressure
	44. Hurry to finish on time
	45. Regularly problems pace work / work load
	46. Should take it easier
	47. Work too tiring
	48. Have to work very fast
	49. A tremendous amount of work
	50. Enough time to finish work
	Recovery time
	51. Feel mentally exhausted
	52. Feel empty after a days work
	53. Feel tired when waking up in the morning
	54. Feel 'burned out'
	55. Feel frustrated by job
	56. Feel work asks too much
	57. Feel at the end of your tether
Office ergonomics	**Work environment factors**
	58. Bothered by light from outside
	59. Bothered by reflection in your monitor
	60. Cold draughts or changes in temperature
	61. Disturbed by noise
	Furniture
	62. Correct height chair
	63. Comfortable chair
	64. Correct height arm rests
	65. Adjustable width arm rests
	66. Correct length arm rests
	67. Correct height desk
	68. Adjustable height desk
	69. Sufficient work surface
	70. Sufficient leg room
	71. Availability footrest

(continued)

Additional file 1. *(continued)*

Main areas	Scales and questions

Computer workstation physical attributes

72. Availability external mouse and keyboard
73. Hindered by length mouse cable
74. Mouse works properly
75. Document holder available
76. Head set
77. Correct height monitor
78. Correct viewing distance monitor

Eyesight

79. Eye complaints (problems focusing, burning- or watery eyes)?

Health — **Prevalence of arm, shoulder and neck symptoms**

DORSAL VIEW
HAND LOWER ARM SHOULDER NECK
WRIST ELBOW UPPER BACK

FRONTAL VIEW
SHOULDER LOWER ARM HAND
NECK ELBOW WRIST
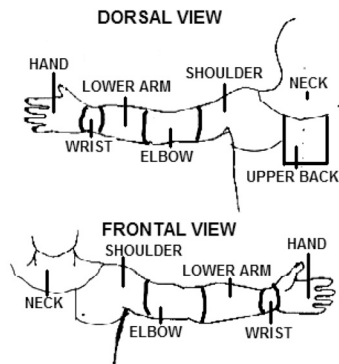
Pain or discomfort in the last **6 months** in:

80. neck
81. upper back
82. shoulder
83. elbow
84. lower arm
85. wrist
86. hand

Pain or discomfort in the last **7 days** in:

87. neck
88. upper back
89. shoulder
90. elbow
91. lower arm
92. wrist
93. hand

94. Pain or discomfort linked to work?
95. Pain or discomfort developed during work?

Additional file 2.

Interventions

Individual Workstation Check

With a one-time visit, the workstation and work behaviour will be assessed with the aid of the 5W's (work tasks, work periods, work pressure, workstation and working method) model. The advisor will pay special attention to ergonomical aspects such as the set-up of the workstation, the furniture, work posture and work organizational factors etc. The advisor will give technical en behavioural advice and will include these in a written report.

Training On-the-Job

As a supplement to the one-time guidance of the workstation check and with the accent on work posture and work techniques of the employee, 'training on the job' will be done in order to achieve a better and permanent effect. During this training, feedback tools are used such as photo or video equipment and/or a muscle tone measurement device.

RSI Counselling Sessions

Low threshold, walk-in counselling will take place within your organization, aimed at prevention, for those employees that have complaints or questions about RSI. The counselling will be done by an Occupational Health Physician or an Occupational Physical Therapist. Depending on the situation, the counselling may consist of a physical check and/or a workstation orientation (with tips and exercises).

Training Course Assertiveness and Negotiation

This training is for supervisors and employees to develop an assertive attitude in their negotiation skills, so that negotiations can be conducted in an effective and pleasant manner. The training takes three half-days.

Individual Coaching

Individual coaching is suitable for employees of all levels. Insight is given into one's own skills and capacities and one learns how to better apply them.

Additional file 2. *(continued)*

Time Management Course

A course designed for employees who want to learn how to deal with stress situations resulting from a high work tempo and heavy work load. As organizations become less hierarchic, it becomes more and more important to be able to manage your own time because no one tells you what to do and when. During the course 'Time Management' one learns especially how to set priorities and stick to them.

Stress Management for Supervisors

Training for supervisors which takes at least three half-days that will enable them to recognize stress signals from employees at an early stage and to communicate about this in a responsible manner on individual and departmental levels.

Handling Stress in the Workplace Course

A training of eight half-days which is aimed at getting insight into stress and stress situations, to improve one's own resistance, learn relaxation techniques and have influence on one's own work situation.

Initiating RSI Policy

Advice will be given for a good RSI policy. Often this involves an approach to RSI that takes several years. The Arbo Unie advisor supports you during the development and the execution stage of that policy.

Education for the Prevention of RSI for Employees

This involves education for groups of employees about RSI, the ergonomical aspects of the workstation and the cause and results of over-burdening. The informative sessions are set up to be practicable, i.e. learning correct work behaviour in one's own work situation. Feedback is done through photo or video recordings; the responsibility of employees themselves will be stressed. In addition, ergonomical improvement possibilities will be discussed.

RSI Education for Supervisors

Your supervisors will learn the risk factors for RSI and how employees with RSI can be guided. Not only the physical ergonomical aspects of RSI but also the psychological risk factors are covered and how to deal with this on an individual level.

Additional file 2. *(continued)*

RSI and Stress

A special training for supervisors and employees about RSI as an organizational problem, the causes of RSI and stress and 'coping' mechanisms will be covered extensively. The training will be given by an ergonomist and a Personnel and Organization expert.

Computer Work Expert Course (train the trainer)

Aimed at ensuring ergonomical workstations, correct work behaviour and correct work posture within a company or organization. After the course, the internal trainer/coach will be able to optimally adjust a workstation for an employee, demonstrate the correct work techniques for present and future employees and give training. He/she will be able to recognize sticky points, correct situations, offer policy options and deal with resistance.

Training Team Building

A training of several half-days with the object to improve the team by making action plans together, learning how to deal with differences and obtaining increased effectiveness.

Team Coaching

Team coaching can contribute to the following: learning to optimally use each others qualities, improving cooperation, increasing productivity of the team and being more flexible and decisive in the face of changes. Team Coaching may be used as a separate tool as well as a continuation of the Team Building in order to coach the implementation of the action plans.

Communication and Co-operation

A practical training of two half-days for supervisors and employees which deals with the basic elements of effective communication.

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CHAPTER **6** CHAPTER

The cost-effectiveness of the RSI QuickScan intervention programme for computer workers: Results of an economic evaluation alongside a randomised controlled trial

Abstract

Introduction: The costs of arm, shoulder and neck symptoms are high. In order to decrease these costs employers implement interventions aimed at reducing these symptoms. One frequently used intervention is the RSI QuickScan intervention programme. It establishes a risk profile of the target population and subsequently advises interventions following a decision tree based on that risk profile. The purpose of this study was to perform an economic evaluation, from both the societal and companies' perspective, of the RSI QuickScan intervention programme for computer workers. In this study, effectiveness was defined at three levels: exposure to risk factors, prevalence of arm, shoulder and neck symptoms, and days of sick leave.

Methods: The economic evaluation was conducted alongside a randomised controlled trial (RCT). Participating computer workers from 7 companies (N=638) were assigned to either the intervention group (N=320) or the usual care group (N=318) by means of cluster randomisation (N=50). The intervention consisted of a tailor-made programme, based on a previously established risk profile. At baseline, 6 and 12 month follow-up, the participants completed the RSI QuickScan questionnaire. Analyses to estimate the effect of the intervention were done according to the intention-to-treat principle. To compare costs between groups, confidence intervals for cost differences were computed by bias-corrected and accelerated bootstrapping.

Results: The mean intervention costs, paid by the employer, were 59 euro per participant in the intervention and 28 euro in the usual care group. Mean total health care and non-health care costs per participant were 108 euro in both groups. As to the cost-effectiveness, improvement in received information on healthy computer use as well as in their work posture and movement was observed at higher costs. With regard to the other risk factors, symptoms and sick leave, only small and non-significant effects were found.

Conclusions: In this study, the RSI QuickScan intervention programme did not prove to be cost-effective from the both the societal and companies' perspective and, therefore, this study does not provide a financial reason for implementing this intervention. However, with a relatively small investment, the programme did increase the number of workers who received information on healthy computer use and improved their work posture and movement.

Trial registration: Trial registration number: NTR1117

Introduction

The costs of musculoskeletal disorders are high, with conservative estimates of the economic burden imposed to the U.S. economy, as measured by compensation costs, lost wages, and lost productivity, between 45 and 54 billion US dollar annually, equalling approximately 0.8% of the gross domestic product [1]. Available cost estimates of musculoskeletal disorders from 15 European countries put the cost between 0.5% and 2% of their gross domestic products [2]. These costs include lost production, staff sickness, compensation and insurance costs, losing experienced staff and recruiting and training new staff, and the effect of discomfort or ill health on the quality of work [2].

Work-related arm, shoulder and neck symptoms are common in Europe, with 25% of the workers reporting work-related neck/shoulder pain, and 15% reporting work-related arm pain [2]. Amongst computer workers, the prevalence of arm, shoulder and neck symptoms is high and cross-sectional studies have reported prevalence rates between 10 and 62% [3]. The total yearly costs of arm, shoulder and neck symptoms in the Netherlands due to decreased productivity, sick leave, chronic disability for work and medical costs were estimated at 2.1 billion Euros [4].

To reduce these costs employers implement interventions aimed at reducing these symptoms. One frequently used intervention, which has recently been developed by an occupational health service in the Netherlands, is the RSI QuickScan intervention programme for computer workers. This multidimensional intervention program addresses a broad spectrum of potential risk factors. It consists of a questionnaire that generates a specific risk profile of the target population, followed by a decision tree for selecting tailor-made interventions [5, 6]. The key cost of the this program are the costs of purchasing the questionnaire and costs of implementing interventions, such as an information or training session, a visit to the occupational physician, an eyesight test, an individual workplace assessment or a task analysis.

Even though interventions aimed at reducing arm, shoulder and neck symptoms are often used, there is a shortage of high quality studies evaluating the cost-effectiveness of these interventions [7]. Two recent reviews evaluating the effectiveness of preventive interventions did not find strong evidence for the effectiveness of interventions and were, therefore, hesitant to give policy recommendations [8, 9]. A recent systematic review by Brewer et al. [8] observed a mixed level of evidence for the general question: 'Do office interventions among computer users have an effect on musculoskeletal or visual health?' Moderate evidence was observed for: (1) no effect of workstation adjustment, (2) no effect of rest breaks and exercise, and (3) a positive effect of alternative pointing devices. A systematic review by Boocock et al. [9], on interventions for the prevention and management of neck/upper extremity musculoskeletal conditions, found moderate evidence for changes to workstation equipment and some evidence that multiple modi-

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fier interventions including or excluding exercise can have positive effects in computer workers with arm, shoulder and neck symptoms.

Because resources to achieve the desired positive effects are often scarce, employers and policy makers need to choose the most cost-effective intervention. This has caused a rapid expansion of research on the economics of occupational health in recent years [10]. To be able to make evidence-based choices on which interventions to implement, reliable information is required on both costs and benefits of interventions. Economic evaluations aim to provide this information. The objective of this study was to evaluate the cost-effectiveness and cost-benefits, from both the societal and companies' perspective of the RSI QuickScan intervention programme for computer workers.

Methods

Design and study population

This economic evaluation was conducted alongside a cluster Randomised Controlled Trial (RCT). Measurements took place at baseline, after 6-months and 12-months. Cost-effectiveness was determined after 12 months. Although the underlying mechanisms for arm, shoulder and neck symptoms are still poorly understood [11], intervention studies [12, 13] and clinical trials [14, 15] that proved to be effective suggest that interventions might be effective on short term, i.e. within 6 months.

The study population consisted of computer workers from 7 Dutch organizations in various branches, in different regions of the Netherlands. Workers with and without arm, shoulder and neck symptoms were included. Of the 1,673 persons who were invited to participate in the study, 1,183 persons (71%) completed the baseline questionnaire. A total of 638 persons (54%) participated at baseline as well as at 6- and 12-months follow-up and were included in the statistical analyses.

The study design, protocols, procedures and informed consent form were approved by the Ethics Committee of the Faculty of Human Movement Sciences of the VU University Amsterdam, and all participants electronically provided informed consent before filling out the baseline questionnaire.

The methodological details of the trial are reported in full elsewhere [6].

Randomisation

The participants were assigned to either the intervention group or the usual care group by means of cluster randomisation (N = 50). To prevent unbalanced randomisation, workers were pre-stratified by the Human Resource Management (HRM) departments of the participating organizations. Organizations were asked to form clusters of approximately the same size and with a comparable amount of computer work. Teams or departments were left intact to avoid crossover effects and to enhance compliance within the intervention groups. The clusters from each organisation were randomly divided into an intervention group and a usual care group. Participants were not informed about their allocation.

Data collection

At baseline, 6- and 12-months follow-up, the workers completed the internet-based RSI QuickScan questionnaire [5] on exposure to risk factors, and the 7-days and 6-months prevalence of arm, shoulder and neck symptoms. The RSI QuickScan investigates the presence or absence of potential risk factors, such as work posture and movement, job decision latitude, relation with management and colleagues, work pace and load, work environment factors, and furniture. A detailed description of the questionnaire can be

found at additional file 1: *http://www.rsiquickscan.com/research/validity/*. For this study, supplementary questions on the use of medical, alternative care resources and the use of pain medication were added.

Intervention group

The intervention group received full feedback on their RSI QuickScan questionnaire results. This feedback consisted of scores on a scale from 1 to 10, an interpretation of the score and elaborate advice on the specific actions that they could personally take in order to reduce exposure to risk factors. If workers reported severe symptoms in the arm, shoulder and neck region, their occupational physician invited them for a consultation. Furthermore, from the information given by the respondents, a risk profile was made, using a traffic light risk assessment system. The risk profile was compiled also for each cluster. If more than 30% of the participants in a cluster had a red score or more than 60% of the participants in a cluster had a red or amber score on a certain risk factor, a tailor-made intervention programme was proposed. Per risk factor a (set of) intervention(s) to be advised to the participating organizations was pre-defined.

A set of 16 interventions aimed at reducing the risk factors in the RSI QuickScan was available. Examples of proposed interventions were: at the individual level: an individual workstation check and an eyesight check; at the group level: an education programme on the prevention of arm, shoulder and neck symptoms and training on handling stress in the workplace. A description of all interventions can be found at additional file 2: *http://www.rsiquickscan.com/research/interventions.pdf.*

Usual care group

The usual care group did not receive elaborate advice on the specific actions that they could personally take after completing the RSI QuickScan, but more general and limited advice. Furthermore, they did not receive interventions based on the risk profile during the time of the study. Given ethical considerations, workers who reported severe symptoms in the arm, shoulder and neck region, 35 cases in this group, were invited by their occupational physician for a consultation. For other supplementary actions the usual care group was put on a waiting list. Consequently, the usual care group received interventions that were similar to those in the intervention group, but only after the study had ended.

Outcome measures

For the economic evaluation, the outcome measures were the same as those in the study evaluating the effectiveness of the RSI QuickScan [6], namely, exposure to risk factors [5], the prevalence of arm, shoulder and neck symptoms, and the number of days of sick leave. The prevalence of arm, shoulder and neck symptoms was estimated with the questionnaire, which specified 7 areas in the arm, shoulder and neck region. The total

symptom score was a continuous measure that consisted of the sum of points scored on the scale arm, shoulder and neck symptoms.

Sick leave was assessed for the 6-month period prior to baseline, and for 6- and 12-month follow-up. This information was gathered from company records provided by the HRM Department, with the advantage of good coverage, accuracy and consistency [16]. The data consisted of total sick leave, maternity leave excluded, and not solely sick leave due to arm, shoulder and neck symptoms.

Cost measurement and valuation

Cost-effectiveness analyses were conducted from both the employers' perspective and the societal perspective. The workers use of medical, alternative care resources and the use of pain medication were measured at baseline and at 6- and 12-month follow-up, using an online questionnaire. These data were used to calculate the direct costs of arm, shoulder and neck symptoms. In the online questionnaire, the workers were asked whether they had used pain medication, anti-inflammatory drugs or a combination of both, due to arm, shoulder and neck symptoms, but not what kind or how many. These costs were therefore estimated and results were subjected to a sensitivity analysis. The costs of 40 tablets of pain medication, anti-inflammatory drugs or a combination of both, were imputed for workers who had used these drugs in the past 6-months period. The costs of visits to a general practitioner, medical specialist and physiotherapist were estimated according to the Dutch manual for costing in economic evaluations [17] and were indexed for 2006, the year in which the trial was performed (Table 1). Other intervention costs, such as the costs of the questionnaire, training and visit to the occupational physician, were provided by the Occupational Health Service and their commercial prices were applied.

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Table 1. *Prices used in the economic evaluation.*

	€ (2006 values)[1]
Direct health care costs	
General practitioner [per visit] [2]	21.03
Medical specialist [per visit] [2]	102.01
Physiotherapist and alternative therapist [per visit] [2]	23.68
Occupational physiotherapist (1 hour) [3]	121.50
Occupational psychologist (1 hour) [3]	126.50
Occupational physician (20 min) [3]	70.00
Direct non-health care costs	
Purchased products aimed at reducing symptoms (range costs)	0 - 50
Intervention costs	
RSI Quickscan - questionnaire [3]	15.00
Information session 'Computer work and RSI' [3]	30.00
Training RSI and Stress [3]	90.00
Consult occupational physician (20 min) [3]	70.00
Eyesight test [3]	20.00
Individual workplace assessment [3]	330.00
Task analyses [3]	60.00
Indirect costs	
Sick leave from paid labour (range costs per hour) [2]	20.89 – 49.78

[1] *€ = US $ 1.27;* [2] *prices according to 'Standardisation of costs: the Dutch manual for costing in economic evaluations', Oostenbrink, 2004. Indirect costs for paid labour were calculated according to the friction cost approach on the basis of the mean income of the Dutch population stratified for age and gender [17];* [3] *prices according to the professional organisation (Occupational Health Service - Arbo Unie)*

Costs were determined by multiplying the volume reported on each cost by the estimated costs per unit. An overview of these costs per unit can be found in Table 1. The costs of private purchases of specific products/tools aimed at reducing arm, shoulder and neck symptoms were taken into account. This information was derived from the questionnaire by two specific questions about this topic. Since these costs may be underreported and are therefore subject to some uncertainty, the effects of a 500% increase of these costs were estimated in a sensitivity analysis. Indirect costs of productivity loss were also taken into account. These costs are not related to health care, but are costs as a consequence of these symptoms, such as sick leave of productive persons in paid labour. Indirect costs caused

by production losses were estimated using the friction cost approach, which assumes that costs are limited to the friction period (i.e. the time it takes to find a replacement), and that the decrease in productivity is less than 100% of the time lost at work (i.e. elasticity) [18]. The friction period was estimated to be 154 calendar days and an elasticity of 0.8 was used [18]. Calculations were based on a mean income of the Dutch working population and indexed for 2006, according to age and gender [17].

Statistical analysis

Only workers who completed all three measurements and questionnaires were included in the analyses. Analyses to estimate the effect of the intervention were done according to the intention-to-treat principle [19]. Resource use, sick leave and costs were calculated per person for the 12-months follow-up period.

Cost data are usually skewed to the right [20]. To compare costs between groups, confidence intervals for cost differences were computed by bias-corrected and accelerated (BCa) bootstrapping with 2000 replications [21]. Non-parametric bootstrapping is often used to analyze cost data, because decision makers need to be able to link the summary measure of cost per person to the overall budget impact and this can only be achieved by the mean [22]. The scores were, therefore, expressed as the mean costs per person for the intervention and usual care group and the difference in mean costs between both groups over 12 months. Costs for paid labour were adjusted for 2006 values.

Cost-effectiveness analysis relates the difference in costs between the intervention and the usual care groups to the difference in effects. A cost-effectiveness analysis was performed on the two risk factors ('information' and 'work posture and movement') that showed a significant positive change in the randomized controlled trial assessing the effects of the RSI QuickScan and on two factors that did not show a significant positive change, 'arm, neck, shoulder symptoms' and the number of 'days of sick leave' [6]. For the cost-effectiveness analysis, effect scores on the scales 'information', 'work posture and movement' and 'arm, neck, shoulder symptoms' were adjusted for baseline. In this analysis, we used the total costs for the outcomes risk factors and prevalence.

In a cost-benefit analysis the effects are expressed as benefits in monetary units. The difference in the monetary costs due to sick leave between the intervention group and the usual care group was calculated. For the cost-effectiveness and cost-benefit analyses, the number of days and costs of sick leave were calculated for the half year period, starting 6-months prior to the last measurement and adjusted for the half year period 6-months prior to baseline. For the cost-effectiveness analysis of the outcome sick leave from a societal perspective, only the direct costs were included to avoid double counting. From the companies' perspective, sick leave is a real expense in the Netherlands where the employer pays 100% of the wage during the first year of sick leave, We included indirect

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costs of sick leave as benefit in the cost-benefit analysis performed from the companies' perspective.

To estimate the incremental cost-effectiveness ratio (ICER), we divided the incremental costs of the intervention group compared with those of the usual care group by the incremental effects for each of the effect measures separately. The uncertainty associated with the incremental cost-effectiveness ratios was analysed by bootstrapping using the bias-corrected percentile method with 5000 replications [23]. The bootstrapped incremental cost/effect pairs were plotted on a cost-effectiveness plane [24], consisting of four quadrants with a horizontal axis indicating the effectiveness of the intervention in relation to the usual care group and the vertical axis indicating the difference in costs between the groups.

Sensitivity analyses were performed in which missing cost data for medicine use were imputed and the costs of private purchases of specific products/tools was increased.

Results

Resource use and costs

In both groups, resource utilization was low and there were no significant differences between the two groups (Table 2).

Table 2. *Utilization, costs and differences in costs during the 12-months follow-up period.*

Resource use and costs	Intervention (n=320) Mean (SD)	Usual care (n=318) Mean (SD)	Intervention – Usual care Difference in costs Mean (95% CI)
General practitioner			
- no of visits	0.37 (1.43)	0.43 (1.39)	
- costs [2]	7.69 (30.12)	9.12 (29.22)	-1.44 (-6.05; 3.18)
Medical specialist			
- no of visits	0.25 (1.37)	0.28 (1.26)	
- costs [2]	25.50 (140.14)	28.55 (128.38)	-3.05 (-23.95; 17.85)
Physical and alternative therapist			
- no of treatment sessions	1.71 (5.68)	1.65 (4.89)	
- costs [2]	40.55 (134.50)	39.02 (115.81)	1.53 (-17.99; 21.05)
Occupational psychologist			
- no of treatment sessions	0.02 (0.21)	0.00 (0.06)	
- costs [3]	2.37 (26.39)	0.40 (7.09)	1.97 (-1.03; 4.98)
Occupational physiotherapy			
- no of treatment sessions	0.17 (1.61)	0.18 (1.06)	
- costs [3]	23.92 (195.11)	21.78 (128.17)	2.14 (-23.54; 27.82)
Occupational health physician			
- no of visits	0.11 (0.68)	0.12 (0.67)	
- costs [3]	7.66 (47.87)	8.59 (46.89)	-0.93 (-8.30; 6.44)
Purchased products aimed at reducing symptoms			
- % yes	14	11	
- costs	0.16 (2.30)	0.03 (0.56)	0.13 (-0.19; 0.44)
Sick leave from paid labour			
- no of days	10.38 (21.31)	12.50 (25.25)	
- costs [2]	1768.18 (3686.11)	2090.78 (4303.91)	-322.60 (-945.48; 300.28)

Utilization, costs and differences in costs (€, 2006 values [1]) of health care, non-health care resources and sick leave per person in the intervention and usual care group during the 12-months follow-up period. [1] € = US $ 1.27; [2] prices according to 'Standardisation of costs: the Dutch manual for costing in economic evaluations', Oostenbrink, 2004. Indirect costs for paid labour were calculated according to the friction cost approach on the basis of the mean income of the Dutch working population stratified for age and gender [17]; [3] prices according to the professional organisation (Occupational Health Service - Arbo Unie).

Physical and alternative therapy were the most frequently used health care resources in both groups, with the highest cost. Approximately 14% of the participants in the study purchased products aimed at reducing symptoms, such as a special computer mouse. However, the mean costs of these products were low compared to the other direct costs, especially compared to sick leave (Table 2).

Table 3. *Utilization rates of interventions, mean intervention costs[2] per person and the difference in mean costs*

Type of utilization	Intervention (n=320)	Usual care (n=318)	*p*-value	Intervention – Usual care Difference in costs
RSI QuickScan [3]				
- *Utilization rate (% yes)*	100	100		
- *Mean costs*	15.00	15.00	.	0
Occupational health physician				
- *Utilization rate (% yes)*	7.8	6.0	0.36	
- *Mean costs (SD)*	5.90 (21.00)	4.40 (17.90)		1.50 (-1.53; 4.54)
Education on the Prevention of RSI for Employees				
- *utilization rate (% yes)*	26.3	0.3	0.00	
- *Mean costs (SD)*	7.88 (13.22)	0.09 (1.68)		7.81 (6.31; 9.25)
RSI and Stress				
- *Utilization rate (% yes)*	24.1	1.9	0.00	
- *Mean costs (SD)*	14.34 (32.99)	1.13 (10.04)		13.21 (9.42; 17.01)
Eyesight check				
- *Utilization rate (% yes)*	18.8	6.9	0.00	
- *Mean costs (SD)*	3.75 (7.82)	1.38 (5.08)		2.37 (1.34; 3.39)
Individual Workstation Check				
- *Utilization rate (% yes)*	2.2	0.9	0.21	
- *Mean costs (SD)*	11.34 (60.22)	6.23 (44.97)		5.12 (-3.15; 13.84)
Task analyses				
- *Utilization rate (% yes)*	1.3	0.0	0.05	
- *Mean costs (SD)*	0.75 (6.68)	0.00 (0.00)		0.75 (0.02; 1.49)

Utilization rates (%) of interventions, mean intervention costs[2] per person and the difference in mean costs (€, 2006 values[1]) between the intervention and usual care groups during the 12-months follow-up period. [1] € = US $ 1.27; [2] prices according to the professional organisation (Occupational Health Service - Arbo Unie); [3] Since there is no variation in intervention costs within the groups, SDs and 95% confidence intervals can not be calculated.

Intervention use and costs

The utilization rates (%) of interventions during the 12-months follow-up period are given in Table 3. All participants, regardless of group allocation, received the RSI QuickScan. There were significant between-group differences in utilization rates for

the 'Education on the prevention of RSI for employees', the training 'RSI and stress', the eyesight check, and task analysis (Table 3). The total mean costs of the interventions were €58.97 and €28.24 in the intervention and usual care group, respectively (Table 4 and 5).

Table 4. *Mean costs for the intervention and usual care group and the difference in mean costs from a societal perspective*

Costs	Intervention (n=320) Mean (SD)	Usual care (n=318) Mean (SD)	Intervention – Usual care Difference in costs Mean (95% CI) [2]
Total intervention costs [3]	58.97 (84.74)	28.24 (56.11)	30.73 (18.78; 41.03)
Total non-health and health care costs 4	107.85 (426.32) _____+	107.49 (284.68) _____+	0.36 (-60.77; 53.04) _____+
Total direct costs	166.82 (436.96)	135.73 (294.55)	31.08 (-22.02; 80.27)

Mean costs per person for the intervention and usual care group and the difference in mean costs (€, 2006 values[1]) between both groups over 12 months. [1] € = US $1.27; [2] 95% confidence interval obtained by bias-corrected and accelerated bootstrapping with 2000 replications; [3] prices according to the professional organisation (Occupational Health Service - Arbo Unie); 4 prices according to 'Standardisation of costs: the Dutch manual for costing in economic evaluations', Oostenbrink, 2004.

Table 5. *Mean costs for the intervention and usual care group and the difference in mean costs from an employer's perspective*

Total direct costs	Intervention (n=320) Mean (SD)	Usual care (n=318) Mean (SD)	Intervention – Usual care Difference in costs Mean (95% CI) [2]
Total intervention costs [3]	58.97 (84.74)	28.24 (56.11)	30.73 (18.78; 41.03)

Mean costs per person for the intervention and usual care group and the difference in mean costs (€, 2006 values[1]) between both groups over 12 months. [1] € = US $1.27; [2] 95% confidence interval obtained by bias-corrected and accelerated bootstrapping with 2000 replications; [3] prices according to the professional organisation (Occupational Health Service - Arbo Unie).

In both groups, the main contributor to the total direct costs were the total non-health and health care costs, which were slightly, but not significant, higher in the intervention group (Table 4). There was a significant difference in total intervention costs. However, there was no significant difference in total direct costs, which is the sum of all intervention, non-health and health care costs (Table 4).

Table 6. *Total direct costs, effects and the difference in mean costs from a societal perspective.*

	Intervention Mean (SD)	Usual care Mean (SD)	Intervention – Usual care Difference costs and effects Mean (95% CI)
information	(N=320)	(N=318)	
Total direct costs	166.82 (436.96)	135.73 (294.55)	31.09 (-26.70; 88.88)
Effects (range 0 -1)	-0.22 (0.51)	-0.10 (0.47)	-0.11 (-0.19; -0.04)
work posture and movement	(N=315)	(N=317)	
Total direct costs	169.23 (440.00)	136.11 (294.94)	33.12 (-25.32; 91.56)
Effects (range 0 - 11)	-0.96 (1.89)	-0.61 (2.00)	-0.35 (-0.66; -0.05)
arm, neck, shoulder symptoms	(N=312)	(N=308)	
Total direct costs	170.55 (441.91)	128.11 (276.04)	42.44 (-15.48; 100.36)
Effects (range 0 – 44)	-1.36 (5.49)	-0.77 (5.92)	-0.59 (-1.48; 0.31)
sick leave from paid labour	(N=320)	(N=318)	
Total direct costs	166.82 (436.96)	135.73 (294.55)	31.09 (-26.70; 88.88)
Effects (days of sick leave)	0.14 (23.71)	-0.30 (23.970)	0.44 (-3.26; 4.14)
Benefits [3] (costs of sick leave)	307.71 (3122.17)	227.51 (2847.64)	80.20 (-383.45; 543.86)

Total direct costs and effects per person for the intervention and usual care group and the difference in mean costs (€, 2006 values [1]) between both groups from a societal perspective. Mean costs and effects for the scales 'information', 'work posture and movement' and 'arm, neck, shoulder symptoms are presented over a 12 months period. A negative effect value for these risk factors represents a reduction in exposure and the desired effect. Mean costs and effects for days- and costs of sick leave are presented over a 6 months period. A positive effect or benefit value for sick leave represents an increase in days or costs of sick leave and an undesired effect. [1] € = US $1.27; [2] 95% confidence interval obtained by bias-corrected and accelerated bootstrapping with 5000 replications; [3] Indirect costs for paid labour were calculated according to the friction cost approach on the basis of the mean income of the Dutch population stratified for age and gender [17].

Cost-effectiveness

The mean societal costs and effects per person over 12 months for the scales 'information', 'work posture and movement' and 'arm, shoulder and neck symptoms' show a significant positive effect for the intervention group on received information on healthy computer use and on work posture and movement, with a relatively small difference in total direct costs between the groups (Table 6). The reduction of arm, shoulder and neck symptoms was more prominent in the intervention group, but not significantly so (Table 6). Days and costs of sick leave were higher in the intervention group. However, it is important to note that the effects and benefits were highly non-significant, as can be derived from the 95% confidence interval of the difference in days and costs of sick leave (Table 6).
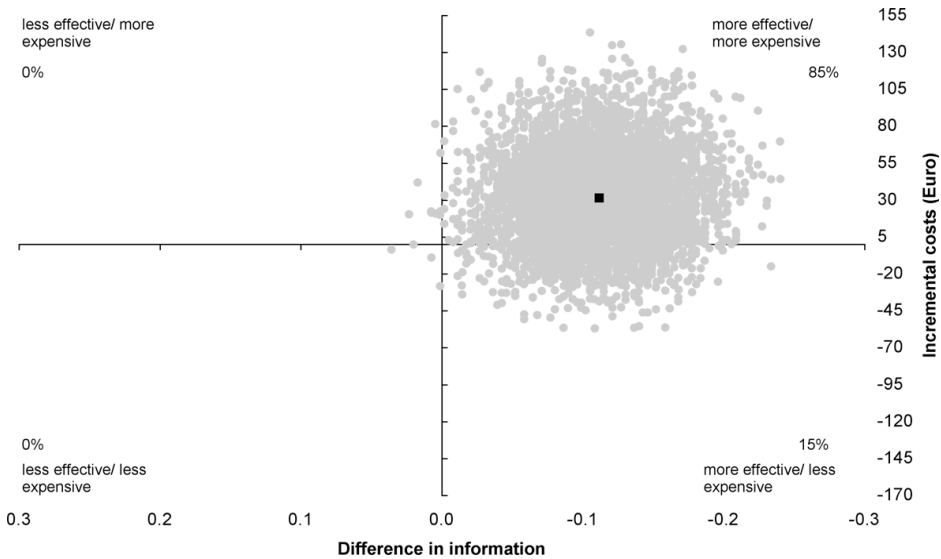
Figure 1. *Cost-effectiveness plane for 'Information'.*
Intervention versus usual care; range 0 - 1. The individual points on the plane represent 5000 bootstrapped cost-effect pairs using the bias-corrected percentile method. The central black dot indicates the point estimate of the incremental cost-effectiveness ratio.

The cost-effectiveness ratio (ICER) for 'information' was estimated at -277.58, indicating that the cost of one point of improvement, which in this case is a negative score since it is a reduction in risk, on a scale ranging from 0 (did receive information on healthy computer use) to 1 (did not receive information on healthy computer use) was estimated at €277.58.

The intervention is significantly more effective with 85% of the incremental cost/effect pairs located in the northeast quadrant and 15% in the southeast quadrant of the cost-effectiveness plane (Figure 1).
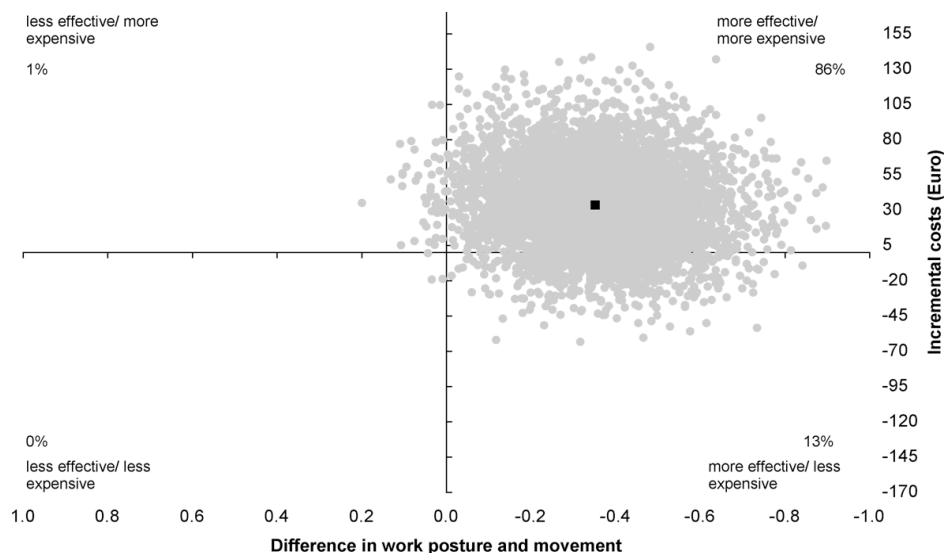
Figure 2. *Cost-effectiveness plane for 'Work posture and movement'.*
Intervention versus usual care; range 0-11. The individual points on the plane represent 5000 boot-strapped cost-effect pairs using the bias-corrected percentile method. The central black dot indicates the point estimate of the incremental cost-effectiveness ratio.

The cost-effectiveness ratio (ICER) for 'work posture and movement' was estimated at -93.82, indicating a cost of €93.82 for one point improvement on a scale ranging from 0 (perfect work posture and movement) to 11 (poor work posture and movement). The intervention was significantly more effective with 86% of the incremental cost/effect pairs located in the northeast quadrant and 13% in the southeast quadrant of the cost-effectiveness plane (Figure 2).

The cost-effectiveness ratio (ICER) for 'the prevalence of arm, shoulder and neck symptoms' indicated that the cost of one point reduction in arm, shoulder and neck symptoms, on a scale ranging from 0 (no arm, shoulder and neck symptoms) to 44 (severe arm, shoulder and neck symptoms) was estimated at €72.55. The intervention was more effective with 87% of the incremental cost/effect pairs located in the northeast quadrant, 8% in the northwest quadrant, 5% in the southeast quadrant and 0% in the southwest quadrant of the cost-effectiveness plane (Figure 3)
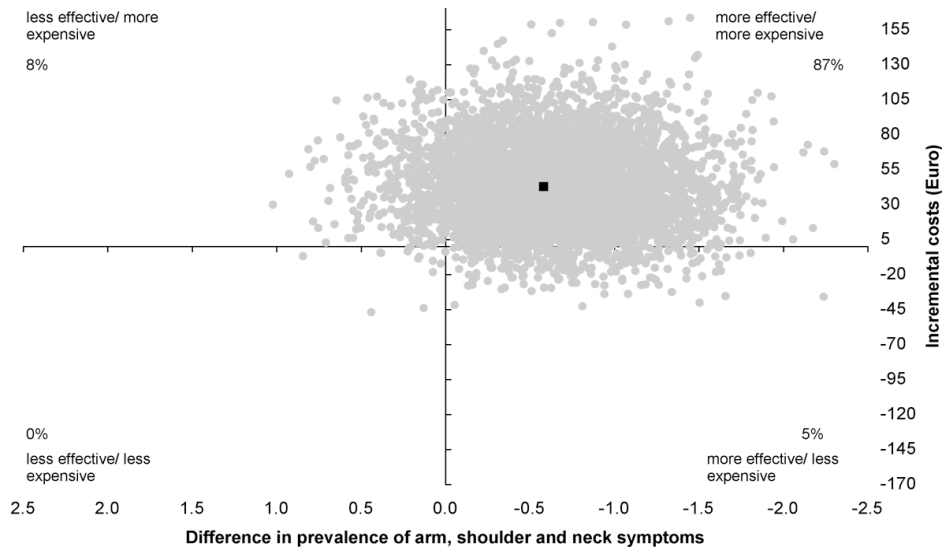
Figure 3. *Cost-effectiveness plane for the prevalence of arm, shoulder and neck symptoms - total symptom score.*
Intervention versus usual care; range 0 - 44. The individual points on the plane represent 5000 boot-strapped cost-effect pairs using the bias-corrected percentile method. The central black dot indicates the point estimate of the incremental cost-effectiveness ratio.

The cost-effectiveness ratio (ICER) for 'days of sick leave' indicated that an investment of €71.31 is associated with in an increase of sick leave by one day. Hence, the intervention was generally less effective with 40% of the incremental cost/effect pairs located in the east quadrants, 61% in the west quadrants of the cost-effectiveness plane (Figure 4). This is, of course, an undesired effect. However, it is important to note that the effect is highly non-significant, as can be seen from the costs-effectiveness plane and the 95% confidence interval of the difference in sick leave days, which ranges from -3.26 to 4.14 (Table 6).

Cost-benefit

The cost-effectiveness ratio (ICER) per point change in cost of sick leave is estimated at €0.39, which means that an investment of €0.39 is associated with an €1 increase of sick leave costs. Obviously, this is an undesirable, but highly non-significant, effect as can be seen from the cost-effectiveness plane (Figure 5), which had 34% of the incremental cost/effect pairs located in the east quadrants, 66% in the west quadrants and the 95% confidence of the difference in sick leave costs (Table 6).
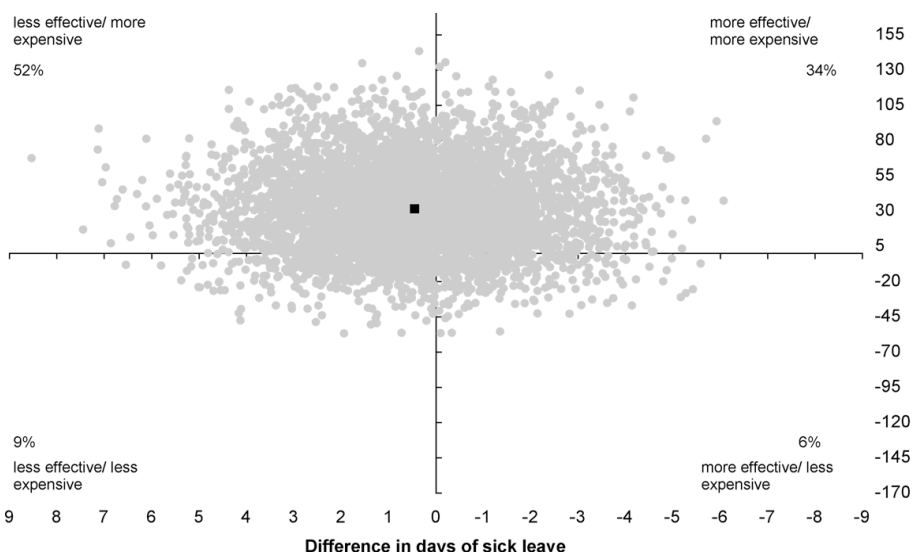
Figure 4. *Cost-effectiveness plane for days of sick leave.*
The individual points on the plane represent 5000 bootstrapped cost-effect pairs using the bias-corrected percentile method. The central black dot indicates the point estimate of the incremental cost-effectiveness ratio.

Sensitivity analysis

Imputation of missing cost data for medicine use increased the costs in the usual care group by €1.42 (SD = 4.45) and in the intervention group by €1.38 (SD = 4.25). The imputation of missing cost data led to a mean difference of €31.02 (95% CI -32.32 to 76.43) in total costs.

Increasing the costs of private purchases of specific products/tools, aimed at reducing arm, shoulder and neck symptoms, by 500% increased the cost in the usual care group to €0.16 (SD = 2.80) and in the intervention group to €0.78 (SD = 13.98). The imputation of missing cost data led to a mean difference of €31.60 (95% CI -19.57 to 84.30) in total costs.
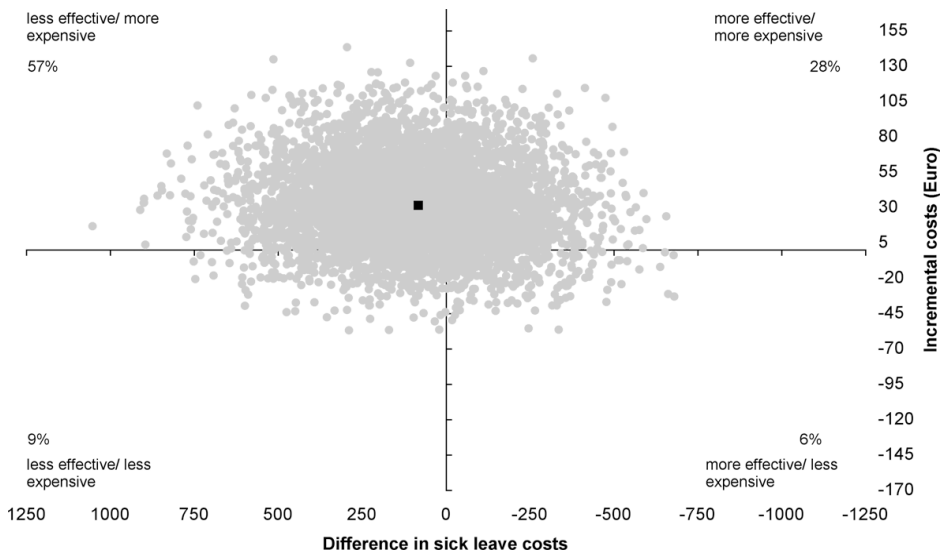
Figure 5. *Cost-effectiveness plane for sick leave costs.*
The individual points on the plane represent 5000 bootstrapped cost-effect pairs using the bias-corrected percentile method. The central black dot indicates the point estimate of the incremental cost-effectiveness ratio.

Discussion

This study evaluated the cost-effectiveness and cost-benefits of the RSI QuickScan intervention programme on exposure to risk factors, prevalence of arm, shoulder and neck symptoms and sick leave in computer workers. This economic evaluation was performed alongside a cluster randomized trial [6]. The intervention was not cost-effective compared to usual care.

Resource use and costs

The results show only small and non-significant differences between the two groups in the total health and non-health care resource use and corresponding costs (€0.36) after 12 months follow-up (Table 4). As expected, resource use and costs of the interventions were significantly higher (€30.73) in the intervention group compared to the usual care group. Total direct costs were higher (€31.08) in the intervention group, but the difference was not significant. In this study, indirect costs due to sick leave was an outcome measure. The cost-effectiveness results in this study are primarily viewed from a societal perspective, because this is the broadest perspective where all costs and effects are taken into account, regardless of who benefits from the health effects or who pays for the costs. However, the cost-effectiveness from an employer's perspective, which is highly relevant to decision makers in organizations, can also be derived from the results presented.

The overall conclusion is that results of the cost-effectiveness analysis performed from a societal perspective are similar to the results of the cost-benefit analysis performed from a companies' perspective. This is due to the fact that there was only a small difference in total non-health and health care costs between the intervention and usual care group of 0.36 euro. From a societal perspective the difference in total direct costs between the usual care and intervention group was 31.08 Euro and from the employer's perspective the difference in total direct costs between the usual care and intervention group was 30.73 Euro.

The monetary investments for the interventions that have to be made by the employer are estimated at €58.97 per person. This investment resulted in an increase in sick leave days and sick leave costs and, therefore, this intervention was not cost-effective.

Limitations of the study

The costs of work-related arm, shoulder and neck symptoms and corresponding sick leave in computer workers are high. One of the major reasons why organizations implement interventions is to decrease these costs [25]. However, the effect of the intervention depends largely on a successful implementation by the management and whether employees are applying the intervention in their daily work or not. In this study, unfortunately, most of the participating organizations did not implement all proposed preventive

measures; although they indicated that they would try to do so at recruitment in the study. The advised package of interventions as a whole was accepted by only one of the seven participating organizations. The other organizations chose parts of the proposed intervention plan, while two organizations even decided to do nothing at all. As a consequence, many workers who should have received an intervention were never offered one, let alone participated in one. This may have added to the limited cost-effectiveness of the RSI QuickScan intervention programme. Which factors impeded the implementation of the interventions will be investigated in a process evaluation. However, the main reason given by the organizations was that their available budget for these interventions was insufficient. Further strengths and weaknesses of the cluster randomized trial have been described extensively elsewhere [6].

Presenteeism

In this study, productivity loss was measured by sick leave. Presenteeism, when the employee is at work, but not fully productive, was not included. Loss of productivity as a result of presenteeism, due to arm, shoulder and neck symptoms, constitutes a substantial economic burden to employers in the Netherlands [4]. The productivity in the case of presenteeism may vary from a relatively small decrease in productivity, to a total loss of productivity. In a study by Martimo et al. [26], workers with arm, shoulder and neck symptoms, on average, lost one third of their regular productivity, which in a normal work day would correspond to 2.5 hours of lost working time. In the RSI QuickScan questionnaire the workers were asked to indicate on a scale from 1 to 10 how efficiently they worked on days when they were at work, but were suffering from arm, shoulder and neck symptoms. Unfortunately, the workers were not asked to quantify the duration of this period, which makes it impossible to estimate the associated costs. Consequently, cost of productivity loss in this study may have been underestimated [27].

Sensitivity analysis

A sensitivity analysis is an important feature in economic evaluations, since study results can be sensitive to the values assumed for by key parameters [22]. The parameters concerning the direct health care costs were estimated according to the prices in the Dutch manual for costing in economic evaluations and adjusted to calendar year 2006 [17]. This manual describes a uniform costing methodology, which makes it easier to interpret and compare studies. The prices in the manual are widely accepted and used for cost-effectiveness studies in the Netherlands. The parameters for intervention costs were the actual prices according to the occupational health service that provided the services. These prices are suitable for use since there is a well functioning, competitive occupational health care market in the Netherlands and the used market prices are not subsidized, nor have they got a high profit margin.

In this study, physical and alternative therapy, such as Cesar/Mensendieck exercise therapy, were the most used health care resources in both groups, with the highest cost. This is quite common in the Netherlands. Approximately 13% of the Dutch population is receiving physical therapy once per year, with an average of 18 visits per person [28].

Imputation of missing cost data for medicine use and increasing the costs of private purchases of specific products/tools aimed at reducing arm, shoulder and neck symptoms in the sensitivity analyses did not change the conclusions of this economic evaluation.

Comparison with other studies

Studies evaluating the (cost-) effectiveness of interventions aimed at reducing arm, shoulder and neck symptoms are scarce [7-9] and no other cost-effectiveness study, in which an advised set of interventions is based on a previously established risk profile, was found in the literature. Therefore, this article provides new information for decision makers and occupational health professionals on the effectiveness and cost-effectiveness of such an intervention strategy for computer workers. Unfortunately, since no similar cost-effectiveness study was found in the literature, the evidence on the lack of effectiveness of this strategy is limited. Still, a few studies on the cost-effectiveness of preventive interventions aimed at reducing arm, shoulder or neck symptoms, in different working populations, have been published in the last decade. A study by Yeow et al. [29] on the cost-effectiveness of simple and inexpensive ergonomic improvements in test workstations of an electronics factory, found average savings in yearly rejection cost (i.e. costs as a results of customers returning defect products), reduction in rejection rate, increase in monthly revenue, improvements in productivity and other benefits. Even though the setting of Yeow's study, an assembly factory in an industrially developing country, was quite different from ours, one of the implemented ergonomic interventions, an optimization of the workstation design, was also one of the interventions used in our study. Several other randomized controlled trials have shown some promising results, but did not include a cost-effectiveness analysis. A study by Ketola et al. [30] that evaluated the effect of an intensive ergonomic approach and education on workstation changes and musculoskeletal disorders among computer workers, found that both the intensive ergonomics approach and education in ergonomics did help to reduce discomfort in computer work. A study by Bohr [31] found that computer workers who received education reported less pain/discomfort and psychosocial work stress following the intervention than those who did not receive education.

Conclusions

In conclusion, the RSI QuickScan intervention programme was not cost-effective compared to usual care. This might be caused by the fact that a large percentage of workers did not receive the advised intervention. For those who did receive an intervention, the duration and intensity of the interventions was often low. However, the programme did increase the number of workers who received information on healthy computer use and improved their work posture and movement at relatively modest costs.

Additional material

Additional file 1. RSI QuickScan questionnaire
The file provides a detailed description of the content of the RSI QuickScan questionnaire. *[http://www.rsiquickscan.com/research/questionnaire.pdf]*
Additional file 2. Interventions in the RSI QuickScan intervention programme.
The file provides a description of all 16 interventions that were part of the RSI QuickScan intervention programme. [http://www.rsiquickscan.com/research/interventions.pdf]

Acknowledgements

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References

[1] **National Research Council IoM**. *Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities. Washington, D.C.: National Academy Press 2001.*

[2] **European Commission**. *First-phase consultation of the social partners on musculoskeletal disorders at work, available online at: http://ec.europa.eu/employment_ social/news/2004/nov/musculoskeletaldisorders_ en.pdf. Brussels; 2004.*

[3] **Wahlstrom J.** *Ergonomics, musculoskeletal disorders and computer work. Occupational Medicine (Lond). 2005;55(3):168-76.*

[4] **Blatter BM, Houtman I, Van den Bossche S, Kraan K, Van den Heuvel S.** *Gezondheidsschade en kosten als gevolg van RSI en psychosociale arbeidsbelasting in Nederland [Health damage and costs of RSI and psychosocial work load in the Netherlands]: Report on demand of The Dutch Ministry of Social Affairs and Employment. TNO Quality of Life; 2005.*

[5] **Speklé EM, Hoozemans MJM, Van der Beek AJ, Blatter BM, Bongers PM, Van Dieën JH.** *Internal consistency, test-retest reliability and concurrent validity of a questionnaire on work-related exposure related to arm, shoulder and neck symptoms in computer workers. Ergonomics. 2009;52(9):1087-103.*

[6] **Speklé EM, Hoozemans MJM, Blatter BM, Heinrich J, Van der Beek AJ, Knol DL, Bongers PM, Van Dieën JH.** *Effectiveness of a questionnaire based intervention programme on the prevalence of arm, shoulder and neck symptoms, risk factors and sick leave in computer workers: A cluster randomised controlled trial in an occupational setting. BMC Musculoskeletal Disorders. 2010;11(1):99.*

[7] **Bongers PM.** *Why is the information on cost effectiveness of interventions to manage neck and upper limb symptoms still lacking, while all stakeholders would benefit from this information? Occupational and Environmental Medicine. 2007;64(5):289-90.*

[8] **Brewer S, Van Eerd D, Amick III BC, Irvin E, Daum KM, Gerr F, Moore JS, Cullen K, Rempel D.** *Workplace interventions to prevent musculoskeletal and visual symptoms and disorders among computer users: a systematic review. Journal of Occupational Rehabilitation. 2006;16:325-58.*

[9] **Boocock MG, McNair PJ, Larmer PJ, Armstrong B, Collier J, Simmonds M, Garrett N.** *Interventions for the prevention and management of neck/upper extremity musculoskeletal conditions: a systematic review. Occupational and Environmental Medicine. 2007;64:291-303.*

[10] **Leigh JP.** *Expanding research on the economics of occupational health [editorial]. Scandinavian Journal of Work, Environment & Health. 2006;32(1):1-4.*

[11] **Visser B, Van Dieën JH.** *Pathophysiology of upper extremity muscle disorders. Journal of Electromyography and Kinesiology. 2006;16(1):1-16.*

[12] **Feuerstein M, Huang GD, Haufler AJ, Miller JK.** *Development of a Screen for Predicting Clinical Outcomes in Patients With Work-Related Upper Extremity Disorders. Journal of Occupational & Environmental Medicine. 2000;42(7):749-61.*

[13] **Gutekunst KR, Fogleman MT.** *An ergonomics program to control cumulative trauma disorders in a manufacturing environment. Human Factors and Ergonomics Society Annual Meeting Proceedings. 1988;4:656-9.*

[14] **Aarås A, Dainoff M, Ro O, Thoresen M.** *Can a More Neutral Position of the Forearm When Operating a Computer Mouse Reduce the Pain Level for Visual Display Unit Operators? A Prospective Epidemiological Intervention Study: Part II. International Journal of Human-Computer Interaction. 2001;13(1):13-40.*

[15] **Faucett J, Garry M, Nadler D, Ettare D.** *A test of two training interventions to prevent work-related musculoskeletal disorders of the upper extremity. Applied Ergonomics. 2002;33(4):337-47.*

[16] **Ferrie JE, Kivimaki M, Head J, Shipley MJ, Vahtera J, Marmot MG.** *A comparison of self-reported sickness absence with absences recorded in employers' registers: evidence from the Whitehall II study. Occupational and Environmental Medicine. 2005;62(2):74-9.*

[17] **Oostenbrink JB, Bouwmans CAM, Koopmanschap MA, Rutten FFH.** *Manual for Costing: Methods and Standard Costs for Economic Evaluations in Health Care (in Dutch). Diemen: Health Insurance Board 2004.*

[18] **Koopmanschap MA, Rutten FFH, Van Ineveld BM, Van Roijen L.** *The friction cost method for measuring indirect costs of disease. Journal of Health Economics. 1995;14(2):171-89.*

[19] **Hollis S, Campbell F.** *What is meant by intention to treat analysis? Survey of published randomised controlled trials. BMJ. 1999;319(7211):670-4.*

[20] **Briggs AH, Gray AM.** *Methods in health service research: Handling uncertainty in economic evaluations of healthcare interventions. BMJ. 1999;319(7210):635-8.*

[21] **Efron B, Tibshirani RJ.** *An introduction to the bootstrap (Monographs on Statistics and Applied Probability). New York: Chapman & Hall 1993.*

[22] **Drummond MF, Sculpher MJ, Torrance GW, O'Brien BJ, Stoddart GL.** *Methods for the economic evaluation of health care programmes. Third ed. Oxford: Oxford University Press 2005.*

[23] **Chaudhary MA, Stearns SC.** *Estimating confidence intervals for cost-effectiveness ratios: an example from a randomized trial. Statistics in Medicine. 1996;15:1447-58.*

[24] **Black WC. The CE Plane**: *A Graphic Representation of Cost-Effectiveness. Medical Decision Making. 1990;10(3):212-4.*

[25] **Burdorf A.** *Economic evaluation in occupational health—its goals, challenges, and opportunities [Editorial]. Scandinavian Journal of Work, Environment & Health. 2007;33(3):161-4.*

[26] **Martimo K-P, Shiri R, Miranda H, Ketola R, Varonen H, Viikari-Juntura E.** *Self-reported productivity loss among workers with upper extremity disorders. Scandinavian Journal of Work, Environment & Health. 2009;35(4):301-8.*

[27] **Lötters F, Meerding W-J, Burdorf A.** *Reduced productivity after sickness absence due to musculoskeletal disorders and its relation to health outcomes. Scandinavian Journal of Work, Environment & Health. 2005;31(5):367-74.*

[28] **Cardol M, Van Dijk L, De Jong JD, De Bakker DH, Westert GP.** *Tweede Nationale Studie naar ziekten en verrichtingenin de huisartspraktijk. Huisartsenzorg: wat doet de poortwachter? Utrecht/Bilthoven: NIVEL/RIVM; 2004.*

[29] **Yeow PHP, Nath Sen R.** *Quality, productivity, occupational health and safety and cost effectiveness of ergonomic improvements in the test workstations of an electronic factory. International Journal of Industrial Ergonomics. 2003;32(3):147-63.*

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[30] **Ketola R, Toivonen R, Hakkanen M, Luukkonen R, Takala EP, Viikari-Juntura E, Ergonomics EG.** *Effects of ergonomic intervention in work with video display units. Scandinavian Journal of Work, Environment & Health. 2002;28(1):18-24.*

[31] **Bohr PC.** *Efficacy of Office Ergonomics Education. Journal of Occupational Rehabilitation. 2000;10(4):243-55.*

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CHAPTER 7 **CHAPTER**

General discussion

Aim and main findings

The aim of this thesis was to: 1) assess the reliability, consistency and validity of the RSI QuickScan questionnaire, and 2) assess the (cost-) effectiveness of the RSI QuickScan intervention programme with respect to the prevalence of arm, shoulder and neck symptoms, exposure to risk factors, and sick leave in a population of computer workers.

In this chapter, the main results of the different studies are summarized and interpreted in light of the three research questions that were posed in the General Introduction. Strengths and weaknesses of the performed studies are discussed and final conclusions are drawn. Recommendations for occupational health practitioners and recommendations for further research are given at the end of this chapter.

Summary of the main findings

Is the RSI QuickScan questionnaire reliable, consistent and valid?
The results show that, firstly, the RSI QuickScan questionnaire, which aims to identify the presumed risk factors for neck, shoulder, and arm symptoms in a population of computer workers, is a measurement tool with acceptable internal consistency, reliability and concurrent validity (chapter 2). Secondly, the RSI QuickScan questionnaire proved to be a moderately valid instrument to collect data on the prevalence of arm, shoulder and neck symptoms, and a valid instrument to collect data on the absence of these symptoms (chapter 3). Thirdly, high scores on 9 out of 13 scales, including previous symptoms, were significantly related to arm, shoulder and neck symptoms at follow-up, which provides support for the predictive validity of the RSI QuickScan questionnaire (chapter 4).

Is the RSI QuickScan intervention programme (cost-) effective in reducing the prevalence of arm, shoulder and neck symptoms, exposure to risk factors, and sick leave in a population of computer workers?
The effectiveness of the RSI QuickScan intervention programme in this study was limited. However, some significant positive effects were found, i.e. an increase in number of workers that had received education and a decrease in exposure to adverse postures and movements. With regard to symptoms and sick leave, only small and non-significant effects were found (chapter 5).

Because of this, the RSI QuickScan intervention programme did not prove to be cost-effective from the societal and companies' perspectives. Therefore, this study did not provide a financial reason for implementing this intervention. However, with a relatively small investment, the programme did increase the number of workers who had received education on healthy computer use and who improved their work posture and movement (chapter 6).

The RSI QuickScan questionnaire

Are we asking the right questions?

The RSI QuickScan questionnaire contains questions on assumed physical and psychoso-cial risk factors. In 2003, the questions in the questionnaire were constructed or selected on the basis of an analysis of the literature on arm, shoulder and neck symptoms and discussions with experts in the field. Since then, various longitudinal studies have been performed [1-4]. Whilst considerable research exists on potential health risks associ-ated with computer work, based on studies with objective measures of computer use, the debate is still ongoing regarding the strength of the evidence to support the hypothesis that computer work is an occupational risk factor for arm, shoulder and neck symptoms [1-3]. The question remains whether the different risk factors in the RSI QuickScan ques-tionnaire are indeed linked to a higher risk of arm, shoulder and neck symptoms.

In the following paragraph, the results of this thesis with regard to the risk factors are summarized, the current state of scientific evidence on the hypothesized relation-ship between several specific risk factors and symptoms is presented, and the associated possible pathophysiological pathways are discussed. Furthermore, the question of whether all scales should still be part of this questionnaire or whether some should be removed is discussed.

Education on healthy computer work

The scale 'information' did not predict arm, shoulder and neck symptoms at any of the investigated time lags in our longitudinal study. Although, education on healthy computer work has been advocated as a prevention method for reducing the incidence and severity of arm, shoulder and neck symptoms [5, 6], the effectiveness of education is debatable [7]. However, it should be recognized that for organisations, this question on education is also important for another reason. Informing employees on healthy computer use and the risks involved with computer work is a requirement by law in the Netherlands. Providing organisations with information on the number of workers that have received education, gives them valuable information on whether their organisa-tion is in compliance with Dutch occupational health law. This may be another reason why ergonomic training is common within many occupational settings. There is some support for effectiveness of education. A study by Bohr [7] showed that workers who received education reported less pain/discomfort and psychosocial work stress following the intervention than those who did not receive education. In two studies by Amick et al. [8] and Robertson et al. [9], a combination of office ergonomics training and a highly adjustable chair showed the best results. When computer workers successfully implement their knowledge of computer workstation ergonomics and work technique this may result in a decrease of musculoskeletal loading. For example, often a computer worker will rest

his/her hand on or just above the mouse, during which the muscles remain activated, for instance, whilst viewing the computer screen or doing something else [3]. When this extended wrist posture is sustained for a long time it is assumed to be a risk factor for developing musculoskeletal symptoms in the arm and hand [10]. Education on healthy computer work may inform computer workers of this risk and teach them to relax the hand by placing it on the desk, when they are not operating the mouse. This may lead to a behavioural change, which may result in less static load and more micro breaks for the upper extremity. In turn, this may prevent muscle damage and, subsequently, prevent muscle disorders. Although, in our study, lack of education on computer work and health did not predict future arm, shoulder and neck symptoms, the reviewed studies did find positive effects [5-9]. Furthermore this question provides the management with valuable information on whether their organisation is in compliance with Dutch occupational health law. Because of the aforementioned, it is suggested that this question should remain to be part of the RSI QuickScan questionnaire.

Duration of computer work
The scale 'work hours' did not predict arm, shoulder and neck symptoms at any of the investigated time lags in our longitudinal study. However, the hypothesized relationship between the (self-reported) duration of computer work and arm, shoulder and neck symptoms has been supported in several investigations [3, 11-15]. A recent review by IJmker et al. [3] provided only moderate evidence for an association between the duration of mouse use and the incidence of hand–arm symptoms. Nevertheless, the duration of computer work may well be a risk factor [4], since the low number of currently available high-quality studies prevents drawing a firm conclusion. The "Cinderella hypothesis" provides a possible explanation why prolonged, low level muscle activity as a result of computer work over a longer duration of time may cause symptoms. Because of the aforementioned, it is suggested that this question should remain to be part of the questionnaire.

Work posture and movement
The scale 'work posture and movement' did predict arm, shoulder and neck symptoms at all investigated time lags in our longitudinal study. Furthermore, several other studies have shown poor work posture and movement to be a possible risk factor for arm, shoulder and neck symptoms [12, 16-20] . Sustained awkward postures, such as increased wrist extension [21] or working with forearm pronation during use of a conventional mouse and keyboard [22], are among the most consistently observed risk factors for arm, shoulder and neck symptoms. Mouse use [1, 3, 23] and extreme wrist postures, e.g. ulnar deviation greater than 20º [12] are assumed to be risk factors. Wrist extension increases the fluid pressure in the carpal tunnel 10-fold and wrist flexion increases it 8-fold [24, 25]

and this may result in median nerve compression at the wrist and, subsequently, carpal tunnel syndrome [26]. Pronation is a posture that may cause increased forearm muscle loads and elevated tissue pressures [22]. Postural invariance is a risk factor for musculoskeletal disorders [27]. Poor work posture and movement may entail sustained muscle activity which results in homeostatic disturbances in muscle tissue and may cause an accumulation of metabolites, stimulating nociceptors [28]. According to the nitric oxide/oxygen ratio hypothesis presented by Eriksen [29], prolonged head-down neck flexion at work may cause neck myalgia when low-level contractions in the trapezius muscle are combined with sympathetic vasoconstriction. Because of the aforementioned, it is suggested that this question should remain to be part of the questionnaire.

Work environment factors

The scale 'work environment factors' did predict arm, shoulder and neck symptoms at two (6 and 18 months) of the four investigated time lags in our longitudinal study. However, it did not yield significant results at the other two time lags (12 and 24 months). Substandard work environment factors (e.g. poor lighting, temperature and acoustic conditions) can elevate stress [30]. As environmental stressors, the physical features and properties of the office can influence physiological processes and limit performance [30]. In a study by Korhonen et al. [31], data were collected using questionnaires, containing questions on physical work environment (lighting conditions, temperature, quality of the air, size of the working room, and acoustic conditions in the work environment). Results from their study showed that a poor physical work environment increased the risk of neck pain. Evans and Johnson [27] found that participants were less likely to make ergonomic, postural adjustments in their computer work station while working under noisy, relative to quiet, conditions. Rocha et al. [32] performed a study on risk factors for musculoskeletal symptoms among call center operators of a bank. Their results showed that inadequate thermal comfort is associated with an increased risk (OR 3.06, 95%CI:1.09-8.62) for neck/shoulder symptoms. As an effect modifier, substandard work environment factors may increase muscle tension and may continuously activate certain muscle fibers. This may result in low-intensity loading due to continuous firing of low threshold motor units. Because of the aforementioned, it is suggested that this question should remain to be part of the questionnaire.

Visual strain and visual discomfort

The scale 'eyesight' did predict arm, shoulder and neck symptoms at all investigated time lags in our longitudinal study. Furthermore, results from a study by Woods [33] showed high prevalence rates of self-reported musculoskeletal pain/discomfort and visual strain symptoms among data processors. Although relatively few studies have investigated visual strain, it has been linked to musculoskeletal symptoms [34]. In an intervention

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study by Aarås et al. [35], the effects of visual strain and visual discomfort were investigated. The ergonomic serial interventions consisted of a new lighting system, new workplaces and finally an optometric examination and corrections if needed. The two intervention groups reported significant improvement of the lighting conditions, as well as of the visual conditions and significantly reduced visual discomfort and glare. Two years after the intervention, a significant reduction of shoulder pain was reported in the intervention groups, parallel with a significant reduction in static trapezius load, while no such reduction was found in the control group. The questionnaire was found to be a reliable and consistent instrument for easily assessing eye complaints in office work. Visual strain and visual discomfort may increase muscle tension and may continuously activate certain muscle fibers [35]. Furthermore, poor eyesight may lead to poor posture, such as an anteroposition of the head and/or elevated shoulders over longer periods of time. This may result in low-intensity loading due to continuous firing of low threshold motor units. Because of the aforementioned, I suggest that a scale on visual strain and visual discomfort should remain to be part of the questionnaire. However, since the current scale consist of merely one question and provides limited information on visual strain and visual discomfort, it is suggested to replace the current scale with the newly developed and more extensive questionnaire on eye-complaints by Steenstra et al. [36].

Furniture

The scale 'furniture' predicted arm, shoulder and neck symptoms at one (12 months) of the four investigated time lags in our longitudinal study. It did not yield significant results at the other three time lags (6, 18 and 24 months). Results from the validation study showed that this scale had a very poor internal consistency. A study by Nelson and Silverstein [37] found that improved chair comfort was associated with a reduction in neck/shoulder/back symptoms. Although several laboratory studies have shown the impact of chair design [38] surprisingly, little evidence exists as to whether office ergonomic interventions significantly reduce musculoskeletal injury incidence [8]. However, poorly designed furniture may prevent workers from assuming a correct work posture and inhibit healthy movement. Poor office furniture may, consequently, facilitate workers to adopt harmful work posture and movement. Therefore, the same pathophysiological hypotheses apply as for poor posture and movement. Since the predictive validity of this scale is limited to only the 12 month time lag and because this scale on furniture previously also has shown to have a very poor internal consistency, it seems advisable to remove the current scale on furniture from the questionnaire. However, the poor results on the predictive validity might be explained by the high standard of office furniture in the study population and may be representative of the situation in the Netherlands, leaving little contrast between ergonomically 'poor' and 'good' furniture. Because of the aforementioned, it should be investigated whether there remains room for improvement

of furniture in the typical Dutch work situation. If so, it is suggested to construct an improved scale on furniture, with sufficient internal consistency, to replace the current scale on furniture. If not so, it is suggested to remove the scale on furniture from the questionnaire.

Workstation physical attributes

The scale 'computer workstation physical attributes' did not predict arm, shoulder and neck symptoms at any of the investigated time lags in our longitudinal study. Results from the validation study showed that this scale had a very poor internal consistency. However, a study by Straker et al. [39], comparing a traditional computer mouse and a vertical computer mouse in uninjured office workers, showed that discomfort tended to be slightly lower for some workers during vertical mouse use. Two studies by Aarås et al. [17, 18] showed that a more neutral position of the forearm and wrist/hand when using Anir mouse reduced significantly the pain in the neck, shoulder, forearm and wrist/hand for computer workers having pain in these areas. The pain reduction lasted for at least 2.5 years. Rempel et al. [21] evaluated the effects of a trackball on upper body pain severity and incident musculoskeletal disorders and found both positive effects and no effects for a trackball compared to a conventional mouse. Two randomised controlled intervention studies have shown that the use of a split, gabled keyboard can reduce or prevent hand and arm pain and musculoskeletal disorders among computer users [40]:
1) Tittaranonda et al. [41] provided evidence that keyboard users may experience a reduction in hand pain after several months of use of some alternative geometry keyboards, and 2) Moore and Swanson [42] showed that fixed-split ergonomic keyboards reduce the incidence of new neck symptoms among an asymptomatic population after extended use. The incidence of underarm and hand symptoms was also lower, but this effect was not statically significant. McLoone and colleagues [43] stated that research has shown that fixed-split, ergonomic keyboards lessen the pain and functional status in symptomatic individuals as well as reduce the likelihood of developing musculoskeletal disorders in asymptomatic typists over extended use. A review by Fagarasanu and Kumar [44] on carpal tunnel syndrome (CTS) due to keyboarding and mouse tasks, concluded that there is a strong evidence of a causal relation between keyboarding and pointing devices on the one hand and CTS occurrence on the other. The prevalence of CTS in the adult general population in the Netherlands is estimated at 0.6% in men and 9.2% in women [45]. The onset of arm, shoulder and neck symptoms may be explained by the same pathophysiological pathways as described for posture and movement, but this remains controversial. The scale on computer workstation physical attributes did not predict arm, shoulder and neck symptoms at any of the investigated time lags in our longitudinal study and previously has shown to have a very poor internal consistency. A systematic review by Brewer et al. [46] on intervention studies among computer users

concluded that the use of an alternative mouse can prevent musculoskeletal disorders. While results from several studies suggest that the use of an alternative computer mouse [17, 18, 39, 40] and keyboard [40-44] may be beneficial, these studies do not provide conclusive evidence that the interventions would result in the primary prevention of arm, shoulder and neck symptoms in a working population. Most of the positive effects are found in symptomatic workers [17, 18, 41, 43]. Therefore, it is suggested to remove the scale on computer workstation physical attributes from the risk profile and only to present this scale to workers with symptoms, thus using this scale in the secondary prevention of symptoms. Furthermore, it is suggested to construct an improved scale on computer workstation physical attributes, with sufficient internal consistency, to replace the current scale on computer workstation physical attributes.

Work tasks

The scale 'work tasks' did predict arm, shoulder and neck symptoms at all of the investigated time lags in our longitudinal study. Harkness et al. [47] found that monotonous work was a strong risk factor for new onset of shoulder pain. Moreover, it has been generally accepted that a posture involving static muscle work increases the risk of developing symptoms [48]. There is evidence that switching tasks coincides with variation of posture [49]. Monotonous work tasks, such as typing for most of the day, are common for office workers [50]. An example of an office worker with monotonous work tasks, and who's case was presented in the introduction chapter [51], is the legal secretary Kristina, who typed for six or seven hours a day. There is evidence that low-intensity loading can result in arm, shoulder and neck symptoms, provided that the loading takes place over a longer period of time [52-55] Therefore, when organising computer work it is important to allow for variation with other work tasks, thereby avoiding working with the computer during all the work time [56]. Because of the aforementioned, it is suggested that the question on monotonous work tasks should remain in the questionnaire.

Decision authority

The scale 'job decision latitude' did predict arm, shoulder and neck symptoms at three (6, 12 and 18 months) of the four investigated time lags in our study. Since the construction of the RSI QuickScan questionnaire, some longitudinal studies on the effect of work-related psychosocial factors on neck and upper extremity symptoms have been published. These studies show that high work demands or little control at work are related to these symptoms. However, this relationship is neither very strong nor very specific [57]. A systematic review on psychosocial risk factors for neck pain found some evidence for a positive relation between neck pain and low decision authority [58]. A prospective cohort study also found indications that low decision authority is a risk factor for neck pain [59]. Psychosocial stressors are not only associated with psychosomatic complaints and health

indicators, but also with musculoskeletal problems, both acute and chronic [60]. As an effect modifier, psychosocial workplace characteristics, such as high mental load and job demands, may increase muscle tension and continuously activate certain muscle fibers. This may result in low-intensity loading due to continuous firing of low threshold motor units. Because of the above, it is suggested that the scale on low decision authority should remain in the questionnaire.

Psychosocial work conditions

The scale 'work relations with management and colleagues' did predict arm, shoulder and neck symptoms at two (6 and 12 months) of the four investigated time lags in our longitudinal study. However, it did not yield significant results at the other two time lags (18 and 24 months). Several studies on adverse psychosocial work conditions have generally found an increased risk for musculoskeletal problems [58, 60, 61]. Crawford and colleagues [56] observed that, although psychosocial factors were found to be implicated in the aetiology of all types of musculoskeletal disorders, they appear to have more of an impact in the neck and shoulder region. As an effect modifier, adverse psychosocial work conditions, may increase muscle tension and continuously activate certain muscle fibers. This may result in low-intensity loading due to continuous firing of low threshold motor units. Although our own results only showed positive results on two of the four time lags, several other studies did find more consistent results. Because of the aforementioned, it is suggested that this scale should remain in the questionnaire.

Work pace and load

The scale 'work pace and load' did predict arm, shoulder and neck symptoms at two (6 and 12 months) of the four investigated time lags in our longitudinal study. However, it did not yield significant results at the other two time lags (18 and 24 months). Results from a review by Griffiths, Mackey and Adamson [62] showed that, in response to workload, deadlines and performance monitoring pressures, many professional workers are encouraged to perform long hours of computer work with high mental demands. Furthermore, their results showed that work at a hectic work pace and with inadequate work breaks is a risk factors for work-related musculoskeletal symptoms [62]. In a review by Bongers et al. [63], an association between at least one work-related psychosocial factor and adverse upper extremity symptoms or signs was found in the large majority of the reviewed studies. High perceived job stress was consistently associated with all upper extremity problems. Unfortunately, drawing firm conclusions on the role of these factors in the aetiology of upper extremity problems was not possible due to the cross-sectional nature of most studies. The objective of a study by Hughes et al. [64] was to quantify the effects of mental workload and time pressure on perceived workload and physiological responses of the distal upper extremity. Their result showed that increased time pressure

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increased muscle activation, key strike force and wrist deviations; and increased mental workload increased key strike force. Moreover, mental workload and time pressure mediated physical risk factors during typing to increase the risk for work-related distal upper extremity disorders. As an effect modifier, adverse psychosocial work conditions, may increase muscle tension and continuously activate certain muscle fibers. This may result in low-intensity loading due to continuous firing of low threshold motor units. Because of the aforementioned, it is suggested that the questions on work pace and load should remain in the questionnaire.

Recovery time

The scale 'recovery time' did predict arm, shoulder and neck symptoms at all investigated time lags in our longitudinal study. In a study by Sluiter et al. [65], results from six studies on work demands were assessed through validated scales. Strong associations between work demands and need for recovery were found in different occupations. The prospective data showed the prognostic value of need for recovery in relation to subjective health complaints and duration of future sickness absence. Sluiter and colleagues concluded that the hypothesised role for work-related fatigue as a link in the causal string of events, that is assumed to exist between repeated adverse work demands and the development of work-related stress reactions, (psychological) overload and, eventually, health problems, was confirmed. The pathophysiology of need for recovery in relation to arm, shoulder and neck symptoms is consistent with previously proposed pathophysiological pathways. Because of the aforementioned, it is suggested that the scale recovery time should remain in the questionnaire.

Arm, shoulder and neck symptoms

The scale 'arm, shoulder and neck symptoms' did predict arm, shoulder and neck symptoms at all investigated time lags in our longitudinal study. Previous arm, shoulder and neck symptoms have shown to be good predictors of future symptoms [66-69]. Since the scale on previous symptoms is a significant predictor of recurrent symptoms, it can be suggested that musculoskeletal symptoms are persistent or recurrent [66]. Results from a study by Descatha et al. [67] showed that positive answers to a self-administered questionnaire were associated with a higher prevalence and incidence of upper extremity musculoskeletal disorders three years later in a population exposed to highly repetitive work. Descatha and colleagues recommended that workers who are highly exposed to repetitive movements should be followed closely in surveillance programmes and to pay special attention to those who report symptoms. Muscle activity can ultimately result in a stimulation of nociceptors. Nociceptor activation may, subsequently, lead to further increased muscle activity. Furthermore, the pain resulting from nociceptor activity can cause increased sympathetic activity leading to decreased blood circulation and increased

levels of muscle activity. In addition, in the long run a reduction of the pain threshold and an increase of pain sensitivity can develop [28, 55]. Because of the aforementioned, it is suggested that the questions on work-related arm, shoulder and neck symptoms should remain in the questionnaire.

Are we asking the right questions?

As noted above, there is no conclusive evidence that computer work or exposure to the risk factors included in the RSI QuickScan questionnaire are an occupational risk factors for arm, shoulder and neck symptoms. However, also recent research indicates that the risk factors in the RSI QuickScan questionnaire may play a role in the onset of arm, shoulder and neck symptoms, partly because there is (moderate) evidence for these risk factors or there is a pathophysiological and etiological plausibility that these factors play a role in the development of arm, shoulder and neck symptoms. Therefore, it is suggested to maintain the current content of the questionnaire except for the three changes to the questionnaire that have been suggested in the previous paragraphs. Firstly, to replace the current scale on visual strain and visual discomfort with the newly developed eye-complaint questionnaire by Steenstra et al. [36]. Secondly, if there appears to be room for improvement in furniture, to construct an improved scale on furniture with sufficient internal consistency, to replace the current scale on furniture. Thirdly, to remove the scale on computer workstation physical attributes from the risk profile and only to present this scale to workers with symptoms. Furthermore, this scale needs to be improved so that is has sufficient internal consistency.

Determining the optimal cut-off points

The aim of the RSI QuickScan questionnaire is to identify risk factors for arm, shoulder and neck symptoms in a population of computer workers on both an individual and a group level. Since the cause of arm, shoulder and neck symptoms can vary from mainly physical, to psychosocial and personal factors, or a combination of all of these, the questionnaire consists of several topics on work and office ergonomics. For each of these topics, it is important to set a cut-off value that will correctly detect as many computer workers as possible with a high risk for arm, shoulder and neck symptoms or symptoms (true positives). Simultaneously, it is important to avoid labelling workers with a low risk for arm, shoulder and neck symptoms or symptoms as positive for the test (false positives). In its current form, cut-off points were determined prior to obtaining infor-mation on the predictive validity. A score of 30% or less of the maximum on a scale was classified as a low risk, colour coded 'green'. A score of 31% to 60% of the maximum on a scale was classified as a medium risk, colour coded 'amber'. A score of 61% or more of the maximum on a scale was classified as a high risk, colour coded 'red'. The optimal cut-off points may vary for the different factors in the RSI QuickScan questionnaire.

From a preventive point of view a high sensitivity (i.e. picking up everyone with a high risk or symptoms) would be preferable, especially if the interventions have no or limited side effects. Determining the optimal cut-off points of each of the scales could improve the quality of the questionnaire. In theory, the optimal cut-off point for arm, shoulder and neck symptoms is achieved with 100% sensitivity, when all respondents who are suffering from serious symptoms are correctly identified by the questionnaire, and with 100% specificity, when all respondents who are not suffering from serious symptoms are also correctly identified. In practice, obtaining perfect sensitivity and specificity in the identification of arm, shoulder and neck symptoms, solely with a questionnaire, will not be feasible. Further research to determine the optimal cut-off points of each of the scales by calculating optimal sensitivity and specificity is recommended.

Usability

Response rate

Besides the clinimetric properties of a questionnaire, usability aspects also play an important role. The RSI QuickScan questionnaire is a self-administered internet-based questionnaire. There are many advantages of online surveys, i.e. that the respondents can fill out the questionnaire at a time and place that suites them best. However, there are also some pitfalls that need to be taken into account. Nielsen and Norman [70] state that, "Studies of user behaviour on the Web find a low tolerance for difficult designs or slow sites. People don't want to wait. And they don't want to learn how to use a home page. There's no such thing as a training class or a manual for a Web site. People have to be able to grasp the functioning of the site immediately after scanning the home page for a few seconds at most." Thus, when a site is not 'user-friendly', respondents will leave the site before they have completed the questionnaire. Even though response representativeness is more important than response rate in survey research, response rate is important if it bears on representativeness [71]. The response rates of the RSI QuickScan questionnaire had a very large variation, ranging from 24% to 97%, depending on the participating organisation. In order to obtain maximal response rates, special attention was given to the usability design of the RSI QuickScan site. This was done by making the navigation easy to understand and quickly to use. To keep respondents motivated to complete the questionnaire, instant and clear feedback on their results was provided. This resulted in a very limited number, approximately 1%, of incomplete questionnaires, after one initial and two reminder e-mails.

Length of the questionnaire

Other important characteristics of a questionnaire are the number of questions it contains, the questionnaire length and the total amount of time needed to complete the questionnaire. In general, a questionnaire should be as concise as possible, because this

will enhance the overall response rate [72, 73]. The low number of incomplete questionnaires suggests that respondents did not find the list too long. The RSI QuickScan questionnaire is usually filled in during work hours. On average, it takes approximately 15 minutes to complete the questionnaire. From an employer's perspective, when the respondent is filling in the questionnaire during work hours, the shorter the questionnaire, the less time is lost. A couple of minutes extra needed to fill in a questionnaire may not seem much, but questionnaires are often used for large groups and it can mean many hours of lost productivity to an employer. Therefore, scales that have not been proven to be of sufficient quality should be improved or removed.

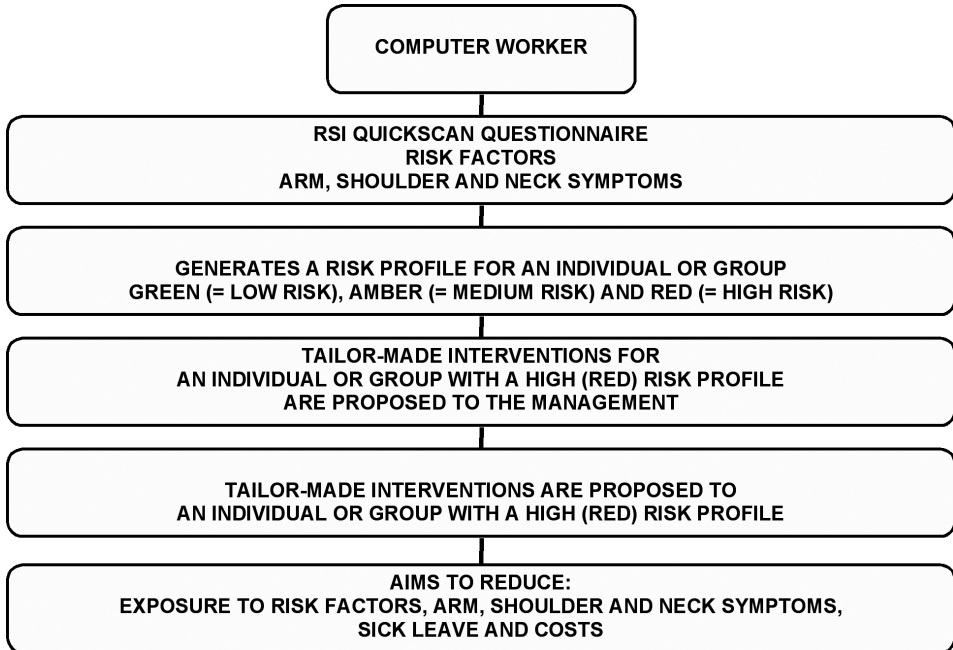# Effectiveness of the RSI QuickScan intervention programme

In case of negative results, one should distinguish between programme and theory failure. The way to do this is to study all steps in the intervention process [74]. Rychetnik and colleagues [75] state that the evaluation of evidence must distinguish between the fidelity of the evaluation process in detecting the success or failure of the implementation of an intervention, and the success or failure of the intervention itself. Moreover, if an intervention is unsuccessful, then the evidence should help to determine whether the intervention was inherently faulty (that is, failure of intervention concept or theory), or just badly delivered (failure of implementation). Even if the rationale behind the intervention is valid, a theory failure may still occur when the dose of the intervention is insufficient. For example, a one hour training session on healthy computer use can provide workers with information on good posture and work technique. In theory, this may lead to less low-intensity loading and fewer symptoms, subsequently. However, in order to achieve a behavioural change with regard to work posture and work technique that will remain over a longer period of time, a longer duration of the training or repeating the training session at certain time intervals, may be needed. Therefore, even if the rationale behind the intervention may be correct, if the dose of the intervention is flawed, then it may be overly optimistic to expect that a relatively modest intervention is enough to catalyze a series of events that could build on each other and lead to significant improvements in the outcome measures.

To assess if a programme or a theory failure, or a combination of both has taken place, the intervention should be evaluated in two ways. Firstly, by evaluating the outcome of the intervention. The results of this evaluation have been described in chapters 5 and 6. Secondly, by evaluating the implementation process. In this process, the factors that impeded or facilitated the process are defined [76].

It is worth noting that the design of our study does not allow conclusions on the effectiveness of single interventions. However, it does allow conclusions on the effectiveness of interventions in combination with the RSI QuickScan questionnaire.

Assessment of the implementation process of interventions

As described in the general introduction, the intervention programme starts with the internet-based RSI QuickScan questionnaire. In case of a high risk on one or more of the scales in the questionnaire, a tailor-made intervention programme was proposed to the management of the organization. When the intervention was accepted by the management, subsequently, a tailor-made intervention programme was proposed to the participants with a high risk profile at baseline (Figure 1).

Figure 1. *Flowchart of the RSI QuickScan intervention programme for computer workers.*

For an intervention to be effective, a successful implementation process is of vital importance. As Kompier notes [77], the success of an intervention may depend more on the implementation process than on the intervention measure itself. Hence, it is important to evaluate not only the interventions, but also the implementation process.

Assessment of the effectiveness of the interventions

The effectiveness of the RSI QuickScan intervention programme was limited. The RSI QuickScan intervention programme comprises a total of 16 interventions, aimed at reducing the risks associated with each of the factors in the RSI QuickScan. However, only six interventions were implemented in the study presented in chapters 5 and 6: a consultation with the occupational health physician, education on the prevention of RSI for employees, a training session on RSI and stress, an eyesight check, an individual workstation check, and a task analysis. Non-implemented interventions were: a training on-the-job, a training course on assertiveness and negotiation, individual coaching, a time management course, a training on stress management for supervisors, a course on handling stress in the workplace, advice on initiating an RSI policy, an RSI education session for supervisors, a computer work expert course (train the trainer), a training on team building, team coaching, and a training on communication and co-operation. The

majority of these non-implemented interventions have an indirect relationship with arm, shoulder and neck symptoms or their risk factors.

The literature on the effects of interventions on arm, shoulder and neck symptoms among computer users is extensive and several systematic reviews of the literature have been performed, summarizing the state of the evidence. Unfortunately, these studies did not find many effective interventions. A review by Boocock et al. [78] did not identify one single intervention strategy that was considered effective for all types of industrial settings. However, they did find some evidence for positive health effects after work environment/workstation adjustments in computer workers with neck/upper extremity conditions. There is some evidence that exercise and other multiple modifier interventions (i.e. cognitive behavioural training and education) have positive effects in workers with neck/upper extremity conditions. Results from a study by Shiri et al. [79] suggest that an early ergonomic intervention reduces sickness absence due to upper-extremity or other musculoskeletal disorders. A systematic review by Brewer et al. [46] found moderate evidence for no effect of workstation adjustments and also no effect of rest breaks together with exercise during the breaks. However, the review did find a positive effect of alternative pointing devices on musculoskeletal outcomes. There was insufficient evidence to determine whether stress management training has an effect on musculoskeletal outcomes since there was only one study. Four studies in the review provided mixed evidence of the effect of ergonomics training on musculoskeletal outcomes. There was insufficient evidence to conclude that lighting, workstation adjustment and computer glasses have an effect on musculoskeletal or visual outcomes with only one study. There was a mixed level of evidence that alternative keyboards have an effect on musculoskeletal outcomes. There was mixed evidence about the effect of breaks on musculoskeletal outcomes. A systematic review by Driessen et al. [80] on the effectiveness of physical and organizational ergonomic interventions on low back pain and neck pain found that ergonomic interventions are usually not effective for preventing or reducing low back pain and neck pain among non-sick listed workers. However, the limited number of RCTs included made it difficult to answer the broad research question and the results should be interpreted with care. A systematic review by Verhagen et al. [81] on the secondary prevention of work related arm, shoulder and neck symptoms found limited evidence for the effectiveness of exercise .

Even though these five reviews did not identify a single intervention strategy with strong evidence (i.e. consistent findings in multiple RCTs of high quality) for effectiveness, Boocock and colleagues did provide some support for a few of the implemented interventions, such as an education on healthy computer work or an individual workstation check [78]. However, it should be noted that these positive findings were obtained in a population of workers with symptoms and not in a general working population. There are other promising interventions, such as exercise and alternative pointing devices, with

some evidence for positive health effects that are currently not part of the RSI QuickScan intervention programme.

Interventions in the RSI QuickScan intervention programme are aimed at reducing the risks associated with each of the factors in the RSI QuickScan. However, interventions might also be aimed at the symptoms that the risk factors are associated with and more specifically at the locations of the symptoms. Although the RSI QuickScan questionnaire does provide information on the location of the symptoms, this information is currently not being used for the selection of specific interventions. Previous research shows that different risk factors of computer work are associated to different effects; e.g. mechanical factors and arm symptoms versus psychosocial aspects and neck/shoulder symptoms [3, 63, 82, 83]. Results from a study by Bloemsaat et al. [82] showed an increased activity of the executive distal musculature during tapping at a higher pace, while the activity of the postural upper limb musculature was elevated due to a memory task. A study by Laursen et al. [83] found increased muscular activity in the neck while working with the mouse when compared to working with the keyboard. This finding may be related to higher visual and mental demands in association with working with the computer mouse than working with the keyboard. In contrast, a systematic review by IJmker et al. [3] found evidence that the duration of mouse use was more strongly and more consistently associated with the incidence of hand/arm symptoms than the duration of total computer use and keyboard use.

Merging all symptomatic regions into one arm, shoulder and neck entity and, thus, not using information on the location of the symptoms for the selection of specific interventions, may have attenuated the effect of the interventions.

Based on experiences in the workplace and combined with results from the literature, the following recommendations are given, which may be beneficial to the effectiveness of the RSI QuickScan intervention programme in the future:

- Aim interventions primarily at workers with (early) symptoms.
- Add exercise and alternative pointing devices to the intervention programme.
- Remove the training course on assertiveness and negotiation, individual coaching, the training on team building, team coaching, and the training on communication and co-operation, from the RSI QuickScan programme.

The last mentioned recommendation is made because these interventions are very rarely implemented, they only have an indirect relation to arm, shoulder and neck symptoms, and there is no evidence that they have a positive effect on arm, shoulder and neck symptoms.

Process evaluation

The limited results of our study may be explained by the partly unsuccessful implementation process of proposed interventions. To further investigate the implementation of

the interventions and to assess the possibility of a programme failure, a process evalua-
tion was performed. The objective of the evaluation of the implementation process was
to investigate which factors impede or facilitate an implementation of RSI interven-
tions among a population of computer workers and give recommendations on how to
improve the implementation of interventions in the future. Unfortunately, no suitable
questionnaires were found that could be used to evaluate the factors influencing the
implementation process of ergonomic interventions in a population of computer workers.
Therefore, two questionnaires for assessing the impeding and facilitating factors on the
implementation processes were constructed; one questionnaire for the management and
one for the employees [84]. The content of the questionnaires was based on previous
studies by Fleuren et al. [85], Saksvik et al. [86], Hulscher et al. [87], and Plas and
Wensing [88]. In order to evaluate the implementation process, managers and workers
of all seven organisations that participated in the randomized controlled trial were
approached for a semi-structured interview. In total 7 managers and 12 employees were
interviewed about the factors that impeded and facilitated the implementation process of
RSI interventions.

   The results showed that factors that are most frequently experienced as impeding, are
related to the organization (i.e. bureaucracy or hierarchical structure) or the individual
(i.e. experience or motivation), whereas factors related to the intervention (i.e. costs or
complexity) itself are least mentioned. The interview results also showed that employees,
in general, experienced more factors as impeding in the total implementation process
than the management. Furthermore, the impeding factors mentioned by employees and
management differed. When the intervention was declined by the management, this was
often caused by a lack of support from the higher management.

   It has long been recognized that a strong commitment of the management is highly
important for a successful implementation of an intervention [89-91] and that inter-
ventions that are less flexible to apply and more time-consuming are more difficult to
implement [77, 89, 92]. Furthermore, the financial aspect of the intervention and the
presumed benefit is important when deciding to accept an intervention [89, 93, 94]. Also
in this study, these factors were shown to be important.

   When a company is restructuring, as was the case with two of the participating
organisations, it will have an important influence on the outcome. For example, one
company that started a reorganisation decided against implementing the interventions
altogether. When an intervention was not accepted, the perceived cost-benefits ratio of
the intervention was more often named as impeding by the management. Compared to
the management, employees more often experienced a lack of motivation, not having
enough knowledge about the intervention, and poor expectations on the effect of the
intervention. Employees experience more complex interventions, such as a lengthy
training session, as more difficult to implement, than simple and less time-consuming

interventions, i.e. a work place adjustment. To facilitate the implementation by workers a participatory ergonomics approach might be a method to increase motivation, to provide enough knowledge about the intervention and to raise expectations on the effect of the intervention [95]. A participatory ergonomics approach enhances meaningful worker participation in the implementation process and can be used as a strategy to improve the implementation of interventions [96-99].

Drawing from our experiences in the RCT combined with the suggestions of others, I would like to give some recommendations which may be beneficial to a successful implementation of ergonomic interventions in a population of computer workers in the future:

- The top management should firmly support the intervention.
- The total intervention costs should be acceptable.
- The intervention should not be complex or time-consuming.
- The whole organization should be motivated to participate in the implementation process.
- The workers should have sufficient knowledge about the intervention.
- The implementation of interventions should not coincide with any major reorganization in the company.

This may be achieved by extensive communication about the intervention itself and the presumed benefit of the intervention. Furthermore, the duration of implementation and the costs of the pre-selected interventions should be acceptable for the organizations. Organizations that are planning to restructure should be excluded prior to the implementation of interventions.

The examined evidence suggests that the limited effectiveness of the RSI QuickScan intervention programme was the result of a programme failure and not of theory failure.

Overall conclusion

In this thesis, five studies were presented. The overall conclusion was that the RSI Quick-Scan questionnaire for computer workers was reliable, consistent and valid. However, the RSI QuickScan intervention programme was not effective in reducing the prevalence of arm, shoulder and neck symptoms, only partly effective in reducing exposure to risk factors, and not effective in reducing sick leave in a population of computer workers. The RSI QuickScan intervention programme for computer workers was not cost-effective. These results are likely the result of a programme failure and not of theory failure.

Recommendations for occupational health practitioners

The results of this study lead to some practical implications for the prevention of arm, shoulder and neck symptoms among computer workers. These practical implications are aimed at professionals in the field of occupational health care, who implement interventions in daily practice.

This study lends support to the use of the RSI QuickScan questionnaire in the assessment of risk factors and symptoms of arm, shoulder and neck in a population of computer workers. The questionnaire can be used as a means to rapidly collect data on the presumed risk factors for arm, shoulder and neck symptoms. It can also be used to assess the prevalence of arm, shoulder and neck symptoms.

The RSI QuickScan intervention programme can be used to increase the level of education and to decrease the exposure to adverse postures and movements. However, this study did not find evidence to support the claim that the RSI QuickScan intervention programme can be used to reduce symptoms or sick leave. Nevertheless, it cannot be ruled out that the RSI QuickScan intervention programme could be effective, especially in the secondary prevention of arm, shoulder and neck symptoms, with a more successful implementation of the interventions.

Professionals in the field should pay more attention to the implementation of proposed interventions, since interventions will only be potentially effective if they are successfully implemented. However, it should be recognized that with regard to the present effectiveness study, both prior and during the trial, extensive attention was given to the implementation process. Furthermore, the management of participating organisations had, prior to the start of the trial, declared their willingness to implement the necessary interventions. Therefore, it may be difficult for other professionals to obtain better results. Professionals should, preferably, advice evidence-based interventions. If these are not available, it is recommended to advice interventions with promising study results or, at least, with a sound theoretical background. Not doing so will likely result in poor effectiveness and will, subsequently, undermine the trust in the quality of services of the occupational health organization and primary and secondary prevention efforts in general. Since only limited evidence on effective interventions is available, interventions for the prevention and management of arm, shoulder and neck symptoms should preferably continue to use multifactorial approaches.

Furthermore, a substantial increase in investment by occupational health services and other stakeholders in high-quality research is recommended. If the professionals in the field do not have sufficient expertise to conduct methodologically sound evaluation studies, it is recommended that they should hire expertise elsewhere. Commercially competing occupational health services should keep in mind that the main interest of occupational health is to provide (cost-) effective interventions to their customers, so that

the health of the workers is improved. More collaboration between occupational health services on the development of evidence-based interventions and research into the (cost-)effectiveness of interventions could be beneficial both from a health perspective and economic perspective.

Recommendations for further research

From the findings in this thesis, some recommendations for further research can be derived:

The RSI QuickScan questionnaire

I recommend further research to determine the optimal cut-off points by calculating optimal sensitivity and specificity for each individual risk factor, including the scale on arm, shoulder and neck symptoms.

With regard to the risk factors, the debate is still ongoing regarding the (strength of the) evidence to support the hypothesis that these risk factors are indeed an occupational risk factor for arm, shoulder and neck symptoms. Therefore, I recommend further epidemiological studies with a longitudinal design, to determine whether the presumed risk factors are, independently or in various combinations, risk factors for arm, shoulder and neck symptoms.

Interventions

As effective interventions are largely lacking, I recommend researchers to perform more high-quality studies evaluating interventions that are aimed at computer workers. Studies should be primarily aimed at interventions that address the major risk factors for arm, shoulder and neck symptoms. In 2004, a study was undertaken to prioritize future research projects on the effectiveness of preventive measures, treatment and rehabilitation programs for upper extremity disorders [100]. The project group composed a top three of promising preventive measures and a top three of promising treatments and rehabilitation programs. Firstly, measures on work-rest schedules in computer or other workers, secondly, measures regarding ergonomic tools or equipment in computer workers, namely alternative ergonomic keyboards, mice or other pointing devices, and thirdly, preventive measures with regard to work tasks, processes and work pressure. High quality research on these measures is still largely lacking and I recommend further research on these promising preventive measures. Furthermore, I recommend additional research on the effect of exercise and posture improvement on prevention of symptoms.

Instead of starting with large scale effectiveness studies in the field, it could be advisable to start with smaller pilot studies in a controlled environment in order to first determine the efficacy of the intervention. Besides being more efficient, this has the advantage that the implementation of interventions can be optimized, thereby eliminating the possibility of a program failure. The absence of a program failure will make it possible to determine the effect of the intervention under ideal conditions. When the intervention yields positive efficacy results in the pilot study, I recommend a follow-up with larger scale studies,

with larger numbers of workers and organisations, to determine the effectiveness of the intervention in the field.

Worldwide a large proportion of people work with a computer and work-related arm, shoulder and neck symptoms occur frequently amongst computer workers. Therefore, it is recommended that international agencies, such as the European Agency for Safety and Health at Work, the international labour organization, the World Health Organization (WHO) and the United States Occupational Safety and Health Administration (OSHA) set out an international research strategy plan targeted at specific high-risk groups and arm, shoulder and neck symptoms. Furthermore, I strongly recommend performing economic evaluations alongside randomised controlled trials, because cost-benefit is an important determinant of management decisions on interventions.

Implementation of the interventions

In most randomised controlled trials, the focus is primarily on the outcome measures, while less attention is being paid to what exactly happened during the trial. This is unfortunate, since insight into the implementation of the different parts of the interventions may yield valuable information for researchers and occupational health professionals who are planning to implement similar interventions. I recommend researchers who are planning to perform a randomised controlled trial to assess the various aspects of the implementation of interventions during the whole study, instead of afterwards, which is more common. This process evaluation during the whole trial helps to explore why the intervention works (or not) and whether this is attributable to the level of implementation. Therefore, researchers should monitor the implementation of interventions closely during trials.

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References

[1] Andersen JH, Harhoff M, Grimstrup S, Vilstrup I, Lassen CF, Brandt LPA, Kryger AI, Overgaard E, Hansen KD, Mikkelsen S. *Computer mouse use predicts acute pain but not prolonged or chronic pain in the neck and shoulder. Occupational and Environmental Medicine. 2008;65(2):126-31.*

[2] Waersted M, Hanvold T, Veiersted KB. *Computer work and musculoskeletal disorders of the neck and upper extremity: A systematic review. BMC Musculoskeletal Disorders. 2010;11(1):79.*

[3] IJmker S, Huysmans MA, Blatter BM, Van der Beek AJ, Van Mechelen W, Bongers PM. *Should office workers spend fewer hours at their computer? A systematic review of the literature. Occupational and Environmental Medicine. 2007;64(4):211-22.*

[4] IJmker S, Huysmans MA, Van der Beek AJ, Knol DL, Van Mechelen W, Bongers PM, Blatter BM. *Software-recorded and self-reported duration of computer use in relation to the onset of severe arm-wrist-hand pain and neck-shoulder pain. Occupational and Environmental Medicine. 2010;PMID: 21045214 .*

[5] Street SL, Kramer JF, Harburn KL, Hansen R, MacDermid JC. *Changes in postural risk and general health associated with a participatory ergonomics education program used by heavy video display terminal users: A pilot study. Journal of Hand Therapy. 2003;16(1):29-35.*

[6] Innes E. *Education and training programs for the prevention of work injuries: do they work? Work. 1997;9:221-32.*

[7] Bohr PC. *Efficacy of Office Ergonomics Education. Journal of Occupational Rehabilitation. 2000;10(4):243-55.*

[8] Amick III BC, Robertson MM, DeRango K, Bazzani L, Moore A, Rooney T, Harrist R. *Effect of Office Ergonomics Intervention on Reducing Musculoskeletal Symptoms. Spine. 2003;28(24):2706-11.*

[9] Robertson M, Amick III BC, DeRango K, Rooney T, Bazzani L, Harrist R, Moore A. *The effects of an office ergonomics training and chair intervention on worker knowledge, behavior and musculoskeletal risk. Applied Ergonomics. 2009;40(1):124-35.*

[10] De Korte EM, De Kraker H, Bongers PM, Van Lingen P. *Effects of a feedback signal in a computer mouse on movement behaviour, muscle load, productivity, comfort and user friendliness. Ergonomics. 2008;51(11):1757-75.*

[11] Punnett L, Bergqvist U. *Visual Display Unit Work and Upper Extremity Musculoskeletal Disorders: A Review of Epidemiological Findings. Arbete och Hällsa. 1997;16:1-161.*

[12] Gerr F, Marcus M, Monteilh C. *Epidemiology of musculoskeletal disorders among computer users: lesson learned from the role of posture and keyboard use. Journal of Electromyography & Kinesiology. 2004;14:25-31.*

[13] Wahlstrom J. *Ergonomics, musculoskeletal disorders and computer work. Occupational Medicine (Lond). 2005;55(3):168-76.*

[14] Chang CH, Amick III BC, Menendez CC, Katz JN, Johnson PW, Robertson M, Dennerlein JT. *Daily computer usage correlated with undergraduate students' musculoskeletal symptoms. American Journal of Industrial Medicine. 2007;50(6):481-8.*

[15] Hakala PT, Rimpela AH, Saarni LA, Salminen JJ. *Frequent computer-related activities increase the risk of neck-shoulder and low back pain in adolescents. European Journal of Public Health. 2006;16(5):536-41.*

[16] Conlon CF, Krause N, Rempel DM.
A randomised controlled trial evaluating an alternative mouse and forearm support on upper body discomfort and musculoskeletal disorders among engineers. Occupational and Environmental Medicine. 2008;65(5):311-8.

[17] Aarås A, Dainoff M, Ro O, Thoresen M.
Can a More Neutral Position of the Forearm When Operating a Computer Mouse Reduce the Pain Level for Visual Display Unit Operators? A Prospective Epidemiological Intervention Study: Part II. International Journal of Human-Computer Interaction. 2001;13(1):13-40.

[18] Aarås A, Dainoff M, Ro O, Thoresen M.
Can a more neutral position of the forearm when operating a computer mouse reduce the pain level for VDU operators? International Journal of Industrial Ergonomics. 2002;30(4-5):307-24.

[19] Cook C, Burgess-Limerick R. *The effect of forearm support on musculoskeletal discomfort during call centre work. Applied Ergonomics. 2004;35(4):337-42.*

[20] Cook C, Burgess-Limerick R, Papalia S. *The effect of upper extremity support on upper extremity posture and muscle activity during keyboard use. Applied Ergonomics. 2004;35(3):285-92.*

[21] Rempel DM, Krause N, Goldberg R, Benner D, Hudes M, Goldner GU. *A randomised controlled trial evaluating the effects of two workstation interventions on upper body pain and incident musculoskeletal disorders among computer operators. Occupational and Environmental Medicine. 2006;63(5):300-6.*

[22] Rempel DM, Bach JM, Gordon L, So Y. *Effects of forearm pronation/supination on carpal tunnel pressure. The Journal of Hand Surgery. 1998;23(1):38-42.*

[23] Brandt LP, Andersen JH, Lassen CF, Kryger A, Overgaard E, Vilstrup I, Mikkelsen S. *Neck and shoulder symptoms and disorders among Danish computer workers. Scandinavian Journal of Work, Environment & Health. 2004;30(5):399-409.*

[24] Werner C-O, Elmqvist D, Ohlin P. *Pressure and Nerve Lesion in the Carpal Tunnel. Acta Orthopaedica. 1983;54(2):312-6.*

[25] Werner R, Armstrong TJ, Bir C, Aylard MK. *Intracarpal canal pressures: the role of finger, hand, wrist and forearm position. Clinical Biomechanics. 1997;12(1):44-51.*

[26] Werner RA, Andary M. *Carpal tunnel syndrome: pathophysiology and clinical neurophysiology. Clinical Neurophysiology. 2002;113(9):1373-81.*

[27] Evans GW, Johnson D. *Stress and Open-Office Noise. Journal of Applied Psychology. 2000;85(5):779-83.*

[28] Johansson H, Arendt-Nielsen L, Bergenheim M, Djupsjöbacka M, Gold JE, Johansson H, Ljubisavljevic M, Mano T, Matre DA, Passatore M, Punnett L, Roatta S, Van Dieën JH, Windhorst U. *Chronic Work-related Myalgia. Neuromuscular Mechanisms Behind Work-related Chronic Muscle Syndromes. Gävle, Sweden: University Press 2003.*

[29] Eriksen W. *Linking work factors to neck myalgia: the nitric oxide/oxygen ratio hypothesis. Medical hypotheses. 2004;62(5):721-6.*

[30] Barling J, Kelloway EK, Frone MR. *Physical Work Environment. Handbook of work stress. Thousand Oaks, California: SAGE Publications 2005.*

7

[31] **Korhonen T, Ketola R, Toivonen R, Luukkonen R, Hakkanen M, Viikari-Juntura E.** *Work related and individual predictors for incident neck pain among office employees working with video display units. Occupational and Environmental Medicine. 2003;60(7):475-82.*

[32] **Rocha LE, Glina DMR, De Fatima Marinho M, Nakasato D.** *Risk Factors for Musculoskeletal Symptoms among Call Center Operators of a Bank in São Paulo, Brazil. Industrial Health. 2005;43(4):637-46.*

[33] **Woods V.** *Musculoskeletal disorders and visual strain in intensive data processing workers. Occupational Medicine (Lond). 2005;55(2):121-7.*

[34] **Abib AH, Dutta SP.** *Epidemiological investigation of workdays lost due to VDT related injuries. Occupational Ergonomics. 1998;1(4):285-90.*

[35] **Aarås A, Horgen G, Bjørset H-H, Ro O, Thoresen M.** *Musculoskeletal, visual and psychosocial stress in VDU operators before and after multidisciplinary ergonomic interventions. Applied Ergonomics. 1998;29(5):335-54.*

[36] **Steenstra I, Sluiter J, Frings-Dresen MHW.** *The eye-complaint questionnaire in a visual display unit work environment: Internal consistency and test-retest reliability. Ergonomics. 2009;52(3):334-44.*

[37] **Nelson NA, Silverstein BA.** *Workplace changes associated with a reduction in musculoskeletal symptoms in office workers. Human Factors. 1998;40(2):337-50.*

[38] **ANSI/HFES.** *100-2007 human factors engineering of computer workstations. Santa Monica, CA: Human Factors and Ergonomics Society 2007.*

[39] **Straker L, Pollock C, Frosh A, Aarås A, Dainoff M.** *An Ergonomic Field Comparison of a Traditional Computer Mouse and a Vertical Computer Mouse in Uninjured Office Workers. Human Factors and Ergonomics Society Annual Meeting Proceedings. 2000;44:356-9.*

[40] **Rempel D, Nathan-Roberts D, Chen BY, Odell D.** *The effects of split keyboard geometry on upper body postures. Ergonomics. 2009;52(1):104-11.*

[41] **Tittiranonda P, Rempel D, Armstrong TJ, Burastero S.** *Effect of four computer keyboards in computer users with upper extremity musculoskeletal disorders. American Journal of Industrial Medicine. 1999;35(6):647-61.*

[42] **Moore JS, Swanson N.** *The effect of alternative keyboards on musculoskeletal symptoms and disorders. In: Harris D, Duffy V, Smith M, Stephanidis C, editors. Proceedings of HCI International; 2003; 2003.*

[43] **McLoone HE, Jacobson M, Hegg C, Johnson PW.** *User-centered design and evaluation of a next generation fixed-split ergonomic keyboard. Work: A Journal of Prevention, Assessment and Rehabilitation. 2010;37(4):445-56.*

[44] **Fagarasanu M, Kumar S.** *Carpal tunnel syndrome due to keyboarding and mouse tasks: a review. International Journal of Industrial Ergonomics. 2003;31(2):119-36.*

[45] **De Krom MCTFM, Knipschild PG, Kester ADM, Thijs CT, Boekkooi PF, Spaans F.** *Carpal tunnel syndrome: Prevalence in the general population. Journal of Clinical Epidemiology. 1992;45(4):373-6.*

[46] **Brewer S, Van Eerd D, Amick III BC, Irvin E, Daum KM, Gerr F, Moore JS, Cullen K, Rempel D.** *Workplace interventions to prevent musculoskeletal and visual symptoms and disorders among computer users: a systematic review. Journal of Occupational Rehabilitation. 2006;16:325-58.*

[47] **Harkness EF, Macfarlane GJ, Nahit ES, Silman AJ, McBeth J.** *Mechanical and psychosocial factors predict new onset shoulder pain: a prospective cohort study of newly employed workers. Occupational and Environmental Medicine. 2003;60(11):850-7.*

[48] **Juul-Kristensen B, Jensen C.** *Self-reported workplace related ergonomic conditions as prognostic factors for musculoskeletal symptoms: the "BIT" follow up study on office workers. Occupational and Environmental Medicine. 2005;62(3):188-94.*

[49] **Van Dieën JH, De Looze MP, Hermans V.** *Effects of dynamic office chairs on trunk kinematics, trunk extensor EMG and spinal shrinkage. Ergonomics. 2001;44(7):739-50.*

[50] **Klein Hesselink J, Houtman I, Hooftman W, Bakhuys Roozeboom M.** *Arbobalans. Hoofddorp: TNO; 2009.*

[51] **Kristina.** *Early signs. RSI and Overuse Injury Association of the ACT 2010 [cited 2010 Nov 10]; Available from: http://www.rsi.org.au*

[52] **Lexell J, Jarvis J, Downham D, Salmons S.** *Quantitative morphology of stimulation-induced damage in rabbit fast-twitch skeletal muscles. Cell and Tissue Research. 1992;269(2):195-204.*

[53] **Gissel H.** *Ca^{2+} accumulation and cell damage in skeletal muscle during low frequency stimulation. European Journal of Applied Physiology. 2000;83(2):175-80.*

[54] **Barbe MF, Barr AE, Gorzelany I, Amin M, Gaughan JP, Safadi FF.** *Chronic repetitive reaching and grasping results in decreased motor performance and widespread tissue responses in a rat model of MSD. Journal of Orthopaedic Research. 2003;21(1):167-76.*

[55] **Visser B, Van Dieën JH.** *Pathophysiology of upper extremity muscle disorders. Journal of Electromyography and Kinesiology. 2006;16(1):1-16.*

[56] **Crawford JO, Laiou E, Spurgeon A, McMillan G.** *Musculoskeletal disorders within the telecommunications sector – A systematic review. International Journal of Industrial Ergonomics. 2008;38(1):56-72.*

[57] **Bongers PM, IJmker S, Van den Heuvel S, Blatter BM.** *Epidemiology of work related neck and upper limb problems: Psychosocial and personal risk factors (Part I) and effective interventions from a bio behavioural perspective (Part II). Journal of Occupational Rehabilitation. 2006;16(3):272-95.*

[58] **Ariëns GAM, Van Mechelen W, Bongers PM, Bouter LM, Van der Wal G.** *Psychosocial risk factors for neck pain: A systematic review. American Journal of Industrial Medicine. 2001;39(2):180-93.*

[59] **Ariëns GAM, Bongers PM, Hoogendoorn WE, Houtman ILD, Van der Wal GMD, Van Mechelen W.** *High Quantitative Job Demands and Low Coworker Support As Risk Factors for Neck Pain: Results of a Prospective Cohort Study. Spine. 2001;26(17):1896-901.*

[60] **Houtman IL, Bongers PM, Smulders PG, Kompier MA.** *Psychosocial stressors at work and musculoskeletal problems. Scandinavian Journal of Work, Environment & Health. 1994;20(2):139-45.*

7

195

[61] **Toomingas A, Theorell T, Michelsen H, Nordemar R.** *Associations between self-rated psychosocial work conditions and musculoskeletal symptoms and signs. Scandinavian Journal of Work, Environment & Health. 1997;23(2):130-9.*

[62] **Griffiths K, Mackey M, Adamson B**. *The Impact of a Computerized Work Environment on Professional Occupational Groups and Behavioural and Physiological Risk Factors for Musculoskeletal Symptoms: A Literature Review. Journal of Occupational Rehabilitation. 2007;17(4):743-65.*

[63] **Bongers PM, Kremer AM, Ter Laak J.** *Are psychosocial factors, risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist?: A review of the epidemiological literature. American Journal of Industrial Medicine. 2002;41(5):315-42.*

[64] **Hughes LE, Babski-Reeves K, Smith-Jackson T.** *Effects of psychosocial and individual factors on physiological risk factors for upper extremity musculoskeletal disorders while typing. Ergonomics. 2007;50(2):261-74.*

[65] **Sluiter JK, De Croon EM, Meijman TF, Frings-Dresen MHW.** *Need for recovery from work related fatigue and its role in the development and prediction of subjective health complaints. Occupational and Environmental Medicine. 2003;60(suppl 1):i62-i70.*

[66] **Juul-Kristensen B, Sogaard K, Stroyer J, Jensen C.** *Computer users' risk factors for developing shoulder, elbow and back symptoms. Scandinavian Journal of Work, Environment & Health. 2004;30:390-8.*

[67] **Descatha A, Chastang JF, Cyr D, Leclerc A, Roquelaure Y, Evanoff B.** *Do workers with self-reported symptoms have an elevated risk of developing upper extremity musculoskeletal disorders three years later? Occupational and Environmental Medicine. 2008;65(3):205-7.*

[68] **Nordlund A, Ekberg K.** *Self reported musculoskeletal symptoms in the neck/shoulders and/or arms and general health (SF-36): eight year follow up of a case-control study. Occupational and Environmental Medicine. 2004;61(3):e11-e.*

[69] **Silverstein BA, Viikari-Juntura E, Fan ZJ, Bonauto DK, Bao S, Smith C**. *Natural course of nontraumatic rotator cuff tendinitis and shoulder symptoms in a working population. Scandinavian Journal of Work, Environment & Health. 2006;32(2):99-108.*

[70] **Nielsen J, Norman DA.** *Usability on the Web isn't a luxury. InformationWeek: ABI/INFORM Global 2000:65-73.*

[71] **Cook C, Heath F, Thompson R.** *A Meta-Analysis of Response Rates in Web- or Internet-Based Surveys. Educational and Psychological Measurement. 2000;60(6):821-36.*

[72] **Don AD, Sinclair MD, Jon RC.** *Effects of Questionnaire Length, Respondent-Friendly Design, and a Difficult Question on Response Rates for Occupant-Addressed Census Mail Surveys. The Public Opinion Quarterly. 1993;57(3):289-304.*

[73] **Heberlein TA, Baumgartner R.** *Factors Affecting Response Rates to Mailed Questionnaires: A Quantitative Analysis of the Published Literature. American Sociological Review. 1978;43(4):447-62.*

[74] **Kristensen TS.** *Intervention studies in occupational epidemiology. Occupational and Environmental Medicine. 2005;62(3):205-10.*

[75] **Rychetnik L, Frommer M, Hawe P, Shiell A.** *Criteria for evaluating evidence on public health interventions. Journal of Epidemiology and Community Health. 2002;56(2):119-27.*

[76] **Westgaard RH, Winkel J.** *Ergonomic intervention research for improved musculoskeletal health: A critical review. International Journal of Industrial Ergonomics. 1997;20(6):463-500.*

[77] **Kompier MAJ, Geurts SAE, Gründemann RWM, Vink P, Smulders PGW.** *Cases in stress prevention: the success of a participative and stepwise approach. Stress Medicine. 1998;14(3):155-68.*

[78] **Boocock MG, McNair PJ, Larmer PJ, Armstrong B, Collier J, Simmonds M, Garrett N.** *Interventions for the prevention and management of neck/upper extremity musculoskeletal conditions: a systematic review. Occupational and Environmental Medicine. 2007;64:291-303.*

[79] **Shiri R, Martimo K-P, Miranda H, Ketola R, Kaila-Kangas L, Liira H, Karppinen J, Viikari-Juntura E.** *The effect of workplace intervention on pain and sickness absence caused by upper-extremity musculoskeletal disorders. Scandinavian Journal of Work, Environment & Health. 2011;37(2):120-8.*

[80] **Driessen MT, Proper KI, Van Tulder MW, Anema JR, Bongers PM, Van der Beek AJ.** *The effectiveness of physical and organisational ergonomic interventions on low back pain and neck pain: a systematic review. Occupational and Environmental Medicine. 2010;67:277-85.*

[81] **Verhagen AP, Karels C, Bierma-Zeinstra SMA, Feleus A, Dahaghin S, Burdorf A, Koes BW.** *Exercise proves effective in a systematic review of work-related complaints of the arm, neck, or shoulder. Journal of Clinical Epidemiology. 2007;60(2):110.e1-.e14.*

[82] **Bloemsaat J, Meulenbroek R, Van Galen G.** *Differential effects of mental load on proximal and distal arm muscle activity. Experimental Brain Research. 2005;167(4):622-34.*

[83] **Laursen B, Jensen BR, Garde A, Jørgensen AH.** *Effect of mental and physical demands on muscular activity during the use of a computer mouse and a keyboard Scandinavian Journal of Work, Environment & Health. 2002;28(4):215-21.*

[84] **Rongen A, Zeeman M.** *Evaluation of the implementation process of RSI interventions. Amsterdam: VU University; 2007.*

[85] **Fleuren MAH, Wiefferink CH, Paulussen TGWM.** *Belemmerende en bevorderende factoren bij de implementatie van zorgvernieuwingen in organisaties. Leiden: TNO Preventie en Gezondheid; 2002.*

[86] **Saksvik PØ, Nytrø K, Dahl-Jørgensen C, Mikkelsen A.** *A process evaluation of individual and organizational occupational stress and health interventions. Work & Stress. 2002;16(1):37-57.*

[87] **Hulscher M, Wensing M, Grol R.** *Effectieve implementatie: theorieën en strategieën. [Effective implementation: theories and strategies]. Den Haag: ZON; 2000.*

[88] **Plas M, Wensing M.** *Begrippenkader voor implementatiestrategieën en beïnvloedende factoren bij implementatie in de gezondheidszorg: WOK; 2006.*

[89] **Whysall ZJ, Haslam RA, Haslam C.** *Processes, barriers, and outcomes described by ergonomics consultants in preventing work-related musculoskeletal disorders. Applied Ergonomics. 2004;35(4):343-51.*

[90] **De Looze MP, Urlings IJM, Vink P, Van Rhijn JW, Miedema MC, Bronkhorst RE, Van der Grinten MP.** *Towards successful physical stress reducing products: an evaluation of seven cases. Applied Ergonomics. 2001;32(5):525-34.*

7

[91] **Goodman G, Landis J, George C, McGuire S, Shorter C, Sieminski M, Wilson T.** *Effectiveness of computer ergonomics interventions for an engineering company: A program evaluation. Work: A Journal of Prevention, Assessment and Rehabilitation. 2005;24(1):53-62.*

[92] **Peters MAJ, Harmsen M, Laurant MGH, Wensing M.** *Ruimte voor verandering? Knelpunten en mogelijkheden voor verbeteringen in de patiëntenzorg. Nijmegen: UMC St Radboud; 2003.*

[93] **Nytrø K, Saksvik PØ, Mikkelsen A, Bohle P, Quinlan M.** *An appraisal of key factors in the implementation of occupational stress interventions. Work & Stress. 2000;14(3):213-25.*

[94] **Droeze EH, Jonsson H**. *Evaluation of ergonomic interventions to reduce musculoskeletal disorders of dentists in the Netherlands. Work: A Journal of Prevention, Assessment and Rehabilitation. 2005;25(3):211-20*

[95] **Van der Molen HF, Sluiter JK, Frings-Dresen MHW.** *Behavioural change phases of different stakeholders involved in the implementation process of ergonomics measures in bricklaying. Applied Ergonomics. 2005;36(4):449-59.*

[96] **Rivilis I, Cole DC, Frazer MB, Kerr MS, Wells RP, Ibrahim S.** *Evaluation of a participatory ergonomic intervention aimed at improving musculoskeletal health. American Journal of Industrial Medicine. 2006;49(10):801-10.*

[97] **Driessen MT, Groenewoud K, Proper KI, Anema JR, Bongers PM, Van der Beek AJ.** *What are possible barriers and facilitators to implementation of a Participatory Ergonomics programme? Implementation Science. 2010;5(1):64.*

[98] **Driessen MT, Proper KI, Anema JR, Bongers PM, Van der Beek AJ.** *Process evaluation of a participatory ergonomics programme to prevent low back pain and neck pain among workers. Implementation Science. 2010;5(1):65.*

[99] **Rivilis I, Van Eerd D, Cullen K, Cole DC, Irvin E, Tyson J, Mahood Q.** *Effectiveness of participatory ergonomic interventions on health outcomes: A systematic review. Applied Ergonomics. 2008;39(3):342-58.*

[100] **Blatter BM, Bongers PM, Van Dieën JH, Van Kempen PM, De Kraker H, Miedema H, Reijneveld CN, De Vet HCW.** *RSI measures: prevention, treatment and return to work. [RSI-maatregelen: preventie, behandeling en reïntegratie]. The Hague: Ministry of Social Affairs and Employment; 2004.*

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SUMMARY

Effectiveness of an intervention programme on arm, shoulder and neck symptoms in computer workers

General introduction

Work-related arm, shoulder and neck symptoms have been known for centuries and are still highly prevalent, especially among computer workers. The costs of these symptoms, both from a health and economic perspective, are high. In an attempt to reduce these costs organizations are implementing various interventions aimed at the prevention of arm, shoulder and neck symptoms. One frequently used intervention that has recently been developed by a large occupational health service in the Netherlands, is the RSI QuickScan intervention programme for computer workers. Instead of using generic strategies, which is common among occupational health services in the Netherlands, this method establishes a risk profile of the target population by using results from the internet-based RSI QuickScan questionnaire. Subsequently, the programme advises interventions following a decision tree based on that risk profile, which may be more effective. This intervention programme is quite unique, as it addresses a broad spectrum of potential risk factors in computer work. The effectiveness of such an intervention programme has not been established yet. Therefore, the objective of this thesis was to assess the reliability, consistency and validity of the RSI QuickScan questionnaire and to assess the (cost-) effectiveness of the RSI QuickScan intervention programme on the prevalence of arm, shoulder and neck symptoms, exposure to risk factors, and sick leave in a population of computer workers.

Internal consistency, test-retest reliability and concurrent validity of the questions on risk factors

Questionnaires are widely used in risk assessments because they provide an efficient method to gather data on large populations, in a short period of time and at low cost. However, a disadvantage of questionnaires is that the collected data may be of limited quality. Therefore, it is important to study whether the RSI QuickScan questionnaire possesses the requisite clinimetric properties to validly assess risk factors. In *chapter 2,* the internal consistency, test-retest reliability and concurrent validity of the RSI QuickScan questionnaire were determined. To study the internal consistency of the RSI QuickScan questionnaire, a population of 86 computer workers was asked to fill out the questionnaire. The internal consistency was calculated using item analysis. The test-retest reliability (N = 86) and concurrent validity (N = 73) were analyzed by calculating the percentage of agreement, Cohen's Kappa, and the Ppositive and Pnegative. The concurrent validity was also tested by comparing the results from the new questionnaire with those from the original questionnaires on which it was based, on-site expert observations, and direct measurements. The results indicate that the RSI QuickScan questionnaire is a measurement tool with acceptable internal consistency, reliability and concurrent validity.

Concurrent validity of the questions on arm, shoulder and neck symptoms

The RSI QuickScan questionnaire also contains questions on arm, shoulder and neck symptoms, which have not previously been validated. To ascertain the clinimetric quality of these questions, in *chapter 3*, the concurrent validity of questions on musculoskeletal symptoms of the RSI QuickScan questionnaire was studied in a study population of 106 computer workers. The agreement between the answers on questions regarding the presence of arm, shoulder and neck symptoms given by workers and physical examinations of the same workers by occupational physicians was determined. In addition, the inter-observer reliability of the physical examinations was explored. The agreement between the symptom questions of the RSI QuickScan questionnaire and physical examinations by occupational physicians can be considered as poor to moderate. However, also the agreement between the occupational physicians themselves can, with a few exceptions, be considered as moderate. The results are comparable to what is generally reported in literature. Good values of the proportion of negative agreement were observed in both the concurrent validity study as well as the inter-observer reliability study. Therefore, it can be concluded that the RSI QuickScan questionnaire is a moderately valid instrument to rapidly collect data on the presence of arm, shoulder and neck symptoms, and a valid instrument to collect data on the absence of these symptoms, in populations of computer workers.

Predictive validity of the questionnaire

The RSI QuickScan intervention programme is based on the assumption that workers with a high score on risk factors and symptoms in the RSI QuickScan questionnaire have a higher risk of having arm, shoulder and neck symptoms in the future. The RSI QuickScan questionnaire has been used as a screening tool for several years, but the predictive validity of the scales in the questionnaire has not previously been determined. Therefore, in *chapter 4*, the predictive validity of the RSI QuickScan questionnaire for the future prevalence of arm, shoulder and neck symptoms among computer workers was determined. For this prospective cohort study, with a follow-up of 24 months, 3383 workers who regularly worked with a computer were approached. Generalized Estimating Equations (GEE) with 6, 12, 18 and 24 months time lags were used to determine whether high exposure to risk factors and previous symptoms were related to symptoms at follow-up. The results showed that high scores on 9 out of 13 scales, including previous symptoms, were significantly related to arm, shoulder and neck symptoms at follow-up. These results provide support for the predictive validity of the RSI QuickScan questionnaire.

Effectiveness of the intervention programme

In *chapter 5*, the effectiveness of the RSI QuickScan intervention programme on exposure to risk factors, the prevalence of symptoms and sick leave in computer workers was studied in a randomised controlled trial. In total, 1673 workers from 7 Dutch organisations in various branches, who regularly worked with a computer, were approached. Of them, 1183 persons completed the baseline questionnaire. The participants were assigned to either the intervention group (28 clusters, N=605) or the usual care group (22 clusters, N=578) by means of cluster randomisation. At baseline and after 12 months of follow-up, the participants completed the RSI QuickScan questionnaire on exposure to the risk factors and on the prevalence of arm, shoulder and neck symptoms. A tailor-made intervention programme was proposed to those departments of organizations or participants in the intervention group with a high risk profile at baseline. Examples of implemented interventions are an individual workstation check or a visit to the occupational physician. The usual care group did not receive interventions based on the risk profile during the time of the study. Analyses to estimate the effect of the intervention were done according to the intention-to-treat principle. The primary outcome measure was the prevalence of arm, shoulder and neck symptoms. Secondary outcome measures were the scores on risk factors and the number of days of sick leave. Sick leave data were obtained from company registers. Multilevel regression analyses were used to test the effectiveness. Statistically significant effects were found as to an increase in receiving education and a decrease in exposure to adverse postures and movements. With regard to the other risk factors, symptoms and sick leave, only small and non-significant effects were found.

Cost-effectiveness of the intervention programme

In *chapter 6* an economic evaluation of the RSI QuickScan intervention programme for computer workers was performed, from both the societal and companies' perspective. The economic evaluation was conducted alongside the randomised controlled trial. To compare costs between the intervention and usual care groups, confidence intervals for cost differences were computed by bias-corrected and accelerated bootstrapping. In this study, the RSI QuickScan intervention programme did not prove to be cost-effective from both the societal and companies' perspective. Therefore, this study does not provide a financial reason for implementing this intervention. However, with a relatively small investment, the programme did increase the number of workers who received information on healthy computer use and the number of workers who improved their work posture and movement.

General discussion

In the last chapter of this thesis, the most important findings of this thesis are summarized and interpreted in light of the three research questions that were posed in the

General Introduction. The strengths and limitations of the various studies are discussed and final conclusions are drawn. Recommendations are made for practical application and future research.

The evidence that the risk factors in the RSI QuickScan questionnaire play a role in the development of symptoms and the possible pathophysiological pathways of these risk factors, are discussed. Several suggestions to improve the RSI QuickScan questionnaire are made. It is concluded that the RSI QuickScan questionnaire for computer workers was reliable, consistent and valid.

The evidence regarding the effectiveness of the interventions and the implementation process of interventions is assessed. A theory failure implicates that an intervention has been perfectly implemented, but the theory is faulty; hence the expected results do not occur. A programme failure implicates that the planned interventions are not delivered; hence the expected results do not occur. The possibility that the results obtained from the intervention studies are due to a programme and theory failure is discussed. It is concluded that these results are likely the result of a programme failure and not of theory failure. It is concluded that the RSI QuickScan intervention programme was not effective in reducing the prevalence of arm, shoulder and neck symptoms, only partly effective in reducing exposure to risk factors, and not effective in reducing sick leave in a population of computer workers. The RSI QuickScan intervention programme for computer workers was not cost-effective.

S

SAMENVATTING

Effectiviteit van een interventieprogramma
op arm-, schouder- en nekklachten
bij beeldschermwerkers

Algemene introductie

Werkgerelateerde arm-, schouder- en nekklachten zijn al eeuwen bekend en komen nog steeds veel voor, in het bijzonder bij mensen die tijdens hun werk een computer gebruiken. De kosten van deze klachten, zowel vanuit een gezondheids als een economisch perspectief, zijn hoog. In een poging deze kosten te reduceren, implementeren organisaties verschillende interventies die gericht zijn op de preventie van arm-, schouder- en nekklachten. Een veelgebruikte interventie die recent is ontwikkeld door een grote arbodienst in Nederland, is het RSI QuickScan interventieprogramma voor beeldschermwerkers. In plaats van generieke strategieën te gebruiken, wat gebruikelijk is bij arbodiensten in Nederland, genereert deze methode een risicoprofiel van de doelgroep met behulp van de resultaten uit de online RSI QuickScan vragenlijst. Op basis van het risicoprofiel selecteert het programma met behulp van een beslisboom interventies. Deze aanpak is mogelijk effectiever dan de gebruikelijke generieke aanpak. Het interventie programma is verder vrij uniek, omdat het zich richt op een breed spectrum van mogelijke risicofactoren die verbonden zijn aan beeldschermwerk. Echter, de effectiviteit van een dergelijk interventieprogramma is nog niet vastgesteld. Daarom is de doelstelling van dit proefschrift om de betrouwbaarheid, consistentie en validiteit van de RSI QuickScan vragenlijst te beoordelen en de (kosten-) effectiviteit van het RSI Quick-Scan interventieprogramma te beoordelen op de prevalentie van arm-, schouder- en nekklachten, de blootstelling aan risicofactoren en ziekteverzuim in een populatie van beeldschermwerkers. Daarom is de doelstelling van dit proefschrift om de betrouwbaarheid, consistentie en validiteit van de RSI QuickScan vragenlijst te beoordelen en de (kosten-) effectiviteit van het RSI QuickScan interventieprogramma te beoordelen op de prevalentie van arm-, schouder- en nekklachten, de blootstelling aan risicofactoren en ziekteverzuim in een populatie van beeldschermwerkers. Daarom heeft dit proefschrift de volgende doelstellingen:

1. Het onderzoeken van de betrouwbaarheid, consistentie en validiteit van de RSI QuickScan vragenlijst.
2. Het onderzoeken van de effectiviteit van het RSI QuickScan interventieprogramma op de prevalentie van arm-, schouder- en nekklachten, de blootstelling aan risicofactoren en ziekteverzuim in een populatie van beeldschermwerkers.
3. Het onderzoeken van de kosten-effectiviteit van het RSI QuickScan interventieprogramma.

Interne consistentie, test-hertest betrouwbaarheid en de concurrente validiteit van de vragen over risicofactoren

Vragenlijsten worden veel gebruikt voor de beoordeling van risico's, omdat hiermee gegevens verzameld kunnen worden over grote populaties, in een korte tijd en tegen lage kosten. Echter, een nadeel van vragenlijsten is dat de verzamelde gegevens van

beperkte kwaliteit kunnen zijn. Daarom is het belangrijk om te onderzoeken of de RSI QuickScan vragenlijst de vereiste klinimetrische eigenschappen bezit om op valide wijze risicofactoren te beoordelen. In *hoofdstuk 2* is de interne consistentie, test-hertest betrouwbaarheid en de concurrente validiteit van de RSI QuickScan vragenlijst bepaald. Voor het onderzoek naar de interne consistentie van de RSI QuickScan vragenlijst is een populatie van 86 beeldschermwerkers gevraagd om de vragenlijst in te vullen. De interne consistentie werd berekend met behulp van item analyse. De test-hertest betrouwbaar-heid (N = 86) en concurrente validiteit (N = 73) werden geanalyseerd door het berekenen van het percentage van overeenkomst, Cohen's Kappa, en de Ppositive en Pnegative. De concurrente validiteit werd getest door het vergelijken van de resultaten van de nieuwe vragenlijst met die van de originele vragenlijsten waarop de RSI QuickScan vragenlijst gebaseerd is, on-site expert waarnemingen en directe metingen. De resultaten geven aan dat de RSI QuickScan vragenlijst een meetinstrument is met een aanvaardbare interne consistentie, betrouwbaarheid en concurrente validiteit.

Concurrente validiteit van de vragen over arm-, schouder- en nekklachten

De RSI QuickScan vragenlijst bevat ook vragen over arm-, schouder- en nekklachten. Deze vragen zijn nog niet eerder gevalideerd. Om de klinimetrische eigenschappen van deze vragen vast te stellen is, in *hoofdstuk 3*, de concurrente validiteit van deze vragen onderzocht in een studiepopulatie van 106 beeldschermwerkers. De mate van overeenkomst is bepaald tussen de antwoorden op vragen over de aanwezigheid van arm-, schouder- en nekklachten die door werknemers zijn gegeven en het lichamelijk onderzoek van dezelfde werknemers door twee bedrijfsartsen. Daarnaast werd de inter-beoordelaarsbetrouwbaarheid van het lichamelijk onderzoek verkend. De overeenkomst tussen de vragen betreffende arm-, schouder- en nekklachten in de RSI QuickScan vragenlijst en het lichamelijk onderzoek door bedrijfsartsen kan worden beschouwd als matig. Echter, ook de overeenkomst tussen de twee bedrijfsartsen zelf kan, op een paar uitzonderingen na, als matig worden beschouwd. De resultaten komen overeen met wat over het algemeen in de literatuur gerapporteerd wordt. Goede waarden van de proportie van negatieve overeenkomst werden waargenomen in zowel het concurrente validiteitsonderzoek als in het interbeoordelaarsbetrouwbaarheidsonderzoek. Daarom kan geconcludeerd worden dat de RSI QuickScan vragenlijst beperkt valide is om snel gegevens te verzamelen over de aanwezigheid van arm-, schouder- en nekklachten en een valide instrument is om gegevens te verzamelen over de afwezigheid van deze klachten in populaties van beeldschermwerkers.

Predictieve validiteit van de vragenlijst

Het RSI QuickScan interventieprogramma is gebaseerd op de veronderstelling dat werknemers met een hoge score op risicofactoren en symptomen in de RSI QuickScan

vragenlijst in de toekomst een hoger risico hebben op arm-, schouder- en nekklachten. De RSI QuickScan vragenlijst is reeds meerdere jaren in gebruik als een screening instrument, maar de predictieve validiteit van de schalen in de vragenlijst is nog niet eerder vastgesteld. Daarom is in *hoofdstuk 4*, de predictieve validiteit van de RSI QuickScan vragenlijst voor de toekomstige prevalentie van arm-, schouder- en nekklachten bij beeldschermwerkers bepaald. Voor deze prospectieve cohort studie met een follow-up van 24 maanden, werden 3383 werknemers benaderd die regelmatig met de computer werkten. Generalized Estimating Equations (GEE) met 6, 12, 18 en 24 maanden tijdsvertragingen werden gebruikt om te bepalen of een hoge blootstelling aan risicofactoren en eerdere klachten gerelateerd zijn aan klachten bij follow-up. De resultaten tonen aan dat hoge scores op 9 van de 13 schalen, met inbegrip van eerdere klachten, sterk gerelateerd zijn aan arm-, schouder- en nekklachten bij follow-up. Deze resultaten bieden ondersteuning voor de predictieve validiteit van de RSI QuickScan vragenlijst.

Effectiviteit van het interventieprogramma

In *hoofdstuk 5* is de effectiviteit van het RSI QuickScan interventieprogramma voor de blootstelling aan risicofactoren, de prevalentie van klachten en ziekteverzuim bij beeldschermwerkers onderzocht in een gerandomiseerd en gecontroleerd onderzoek. In totaal werden 1.673 werknemers uit zeven Nederlandse organisaties in diverse branches, die regelmatig met een computer werkten, benaderd. Van hen voltooide 1.183 personen de baseline vragenlijst. De deelnemers werden door middel van cluster randomisatie toegewezen aan de interventiegroep (28 clusters, N = 605) of de controlegroep (22 clusters, N = 578). Bij aanvang en na 12 maanden follow-up, vulden de deelnemers de RSI QuickScan vragenlijst in over de blootstelling aan de risicofactoren en de prevalentie van arm-, schouder- en nekklachten. Een op maat gemaakt interventieprogramma werd voorgesteld aan de afdelingen van de organisaties of aan de deelnemers in de interventiegroep met een hoog risicoprofiel op baseline. Voorbeelden van uitgevoerde interventies zijn een individueel werkplekonderzoek of een bezoek aan de bedrijfsarts. De controlegroep heeft geen interventies ontvangen die gebaseerd zijn op het risicoprofiel tijdens de studie. Analyses om het effect van de interventie te schatten werden uitgevoerd volgens het intention-to-treat principe. De primaire uitkomstmaat was de prevalentie van arm-, schouder- en nekklachten. Secundaire uitkomstmaten waren de scores op de risicofactoren en het aantal dagen ziekteverzuim. Ziekteverzuim gegevens werden verkregen uit de bedrijfsregisters. Multilevel regressie-analyses werden gebruikt om de effectiviteit te onderzoeken. Statistisch significante effecten werden gevonden met betrekking tot een toename in het ontvangen van voorlichting en een daling in de blootstelling aan ongunstige houdingen en bewegingen op het werk. Met betrekking tot de andere risicofactoren, klachten en ziekteverzuim, werden slechts kleine en niet-significante effecten gevonden.

Kosten-effectiviteit van het interventieprogramma

In *hoofdstuk 6* is een economische evaluatie van het RSI QuickScan interventie-
programma voor beeldschermwerkers uitgevoerd, zowel vanuit een maatschappelijk- als
een bedrijfsperspectief. De economische evaluatie werd uitgevoerd naast het gerandomis-
eerde en gecontroleerde onderzoek (*hoofdstuk 5*). Om de kosten tussen de interventie- en
de controlegroep te vergelijken, zijn de betrouwbaarheidsintervallen voor de schattingen
van de verschillen in kosten berekend door middel van bias gecorrigeerde en versnelde
bootstrapping. In dit onderzoek is het RSI QuickScan interventieprogramma, vanuit
zowel een maatschappelijk- als een bedrijfsperspectief, niet kosten-effectief gebleken.
Daarom biedt dit onderzoek geen financiële reden voor de uitvoering van dit inter-
ventieprogramma. Echter, voor een relatief kleine investering biedt het programma
een toename in het aantal werknemers dat informatie heeft ontvangen over gezond
computergebruik en een toename van werknemers die hun werkhouding en werktech-
niek hebben verbeterd.

Algemene bespreking

In het laatste hoofdstuk van dit proefschrift worden de belangrijkste bevindingen van
dit proefschrift samengevat en geïnterpreteerd in het licht van de drie onderzoeksvragen
die zijn gesteld in de algemene inleiding. De sterke punten en de beperkingen van de
verschillende studies worden besproken en de definitieve conclusies worden getrokken.
Verder worden aanbevelingen gedaan voor de praktische toepassing en toekomstig
onderzoek. Het bewijs dat de risicofactoren in de RSI QuickScan vragenlijst een rol
spelen in de ontwikkeling van de klachten en de mogelijke pathofysiologische paden
van deze risicofactoren worden besproken. Een aantal suggesties om de RSI QuickScan
vragenlijst te verbeteren worden gedaan. Geconcludeerd wordt dat de RSI QuickScan
vragenlijst voor beeldschermwerkers betrouwbaar, consistent en valide is. De gegevens
over de effectiviteit van de interventies en het implementatieproces van interventies
worden beoordeeld, onder andere door te kijken naar de mate van theoriefalen en
programmafalen. Theoriefalen impliceert dat een interventie perfect is uitgevoerd, maar
dat de achterliggende theorie niet klopt en daarom doen de verwachte resultaten zich niet
voor. Programmafalen impliceert dat de geplande interventies niet worden uitgevoerd
waardoor de verwachtte resultaten zich niet voor doen. Geconcludeerd wordt dat het
niet vinden van significante effecten waarschijnlijk het gevolg is van programmafalen
en niet van theoriefalen. Geconcludeerd wordt dat het RSI QuickScan interventiepro-
gramma niet effectief is in het verminderen van de prevalentie van arm-, schouder- en
nekklachten, slechts ten dele effectief is in het verminderen van de blootstelling aan
risicofactoren en niet effectief is in het verminderen van ziekteverzuim in een populatie
van beeldschermwerkers. Het RSI QuickScan interventieprogramma voor beeldscherm-
werkers was niet kosten-effectief.

About the Author

Erwin Martijn Speklé was born on November 10th 1965 in Oosterbeek (Renkum), The Netherlands. He completed his secondary education at the Thomas à Kempis College in Arnhem in 1984. In the same year he continued his education abroad, at the Edwin O. Smith High School in Storrs, Connecticut, U.S.A., of which he graduated one year later. In 1985 he started studying physiotherapy at the University of Applied Sciences Leiden (UAS Leiden, in Dutch: Hogeschool Leiden). In 1997 he transferred to the International Academy of Physiotherapy Thim van der Laan in Utrecht, where he graduated from in 1990.

In 1991 he moved to the west coast of Norway, where he worked as an ergonomist for several occupational health services until 1999. Between 1992 and 1999 he followed extensive training in the field of occupational health, which started with the Basic Course for Occupational Health Service personnel at the Norwegian National Institute of Occupational Health in Oslo. For several years he served as a board member of the NFF - Ergonomics group, a sub group of the Norwegian Physiotherapist Association and he was an active member of the Norwegian Ergonomics Society (NEF) and the Nordic Ergonomics Society (NES).

Since 1999 he is working as an ergonomist at Arbo Unie OHS in Haarlem, where he is involved in consultancy projects for a broad range of organisations. Between 2000 and 2002 he completed a postgraduate education on "ergonomics in the working environment" and received the title Professional Master of Ergonomics. The education is a joint effort of VU University Amsterdam, TU Twente, TU Delft and the University of Amsterdam. In 2004 he founded the Arbo Unie Expertise Center RSI, which he still leads. Since 2006 he is accredited with the title European Ergonomists (Eur.Erg.) by the Centre for Registration of European Ergonomists (CREE).

In 2004 he started his PhD-project named: "Effectiveness of an intervention programme for arm, shoulder and neck symptoms in computer workers". The project was funded by the Netherlands Organization for Health Research and Development (ZonMw) and the Foundation Arbo Unie Netherlands. During this time he followed several courses on epidemiology and biostatistics at the master's programme of EpidM, VU Medical Center.

His current position is senior expert, head of the Expertise Center RSI and team leader at Arbo Unie.

Arbo Unie

Arbo Unie is the largest independent, certified occupational health service in the Netherlands. For more than 100 years, Arbo Unie has been helping people and organizations to perform better. To do so, we use a multidisciplinary approach. We advise workers and employers on matters such as: absenteeism policy, risk management and the vitality of employees. Arbo Unie is a partner of leading scientific institutes for new knowledge and techniques. Arbo Unie has Expert Centers for several themes and branches.
www.arbounie.nl

Body@Work –Research Center on Physical Activity, Work and Health

Body@Work is a joint initiative of TNO Quality of Life, Leiden, The Netherlands and VU University, and VU University Medical Center, Amsterdam, The Netherlands. Our research center focuses on the research topics "work and health" and "lifestyle, health and sports". For these topics, we provide state of the art knowledge for fellow researchers and policymakers of governmental and commercial institutes.
www.bodyatwork.nl

Improve to MOVE

VU University Research Institute MOVE is a collaboration between researchers of the Faculty of Human Movement Sciences, VU University Medical Center and the Academic Center for Dentistry Amsterdam. The research of MOVE is related to human movement and health, with an emphasis on prevention and recovery of injury and disorders of the (neuro-) musculoskeletal system, on optimal recovery of tissue and function, and on motor control and coordination. MOVE aims at fundamental, multidisciplinary and translational research, especially in the fields of (oral) regenerative medicine, rehabilitation and sports.
www.move.vu.nl

Publications

Publications part of this thesis

Speklé EM, Hoozemans MJM, Van der Beek AJ, Blatter BM, Bongers PM, Van Dieën JH. *Internal consistency, test-retest reliability and concurrent validity of a questionnaire on work-related exposure related to arm, shoulder and neck symptoms in computer workers. Ergonomics. 2009;52(9):1087-103.*

Hoozemans MJM, Speklé EM, Van Dieën JH. *Concurrent validity of questions on arm, shoulder and neck symptoms of the RSI QuickScan. Submitted.*

Speklé EM, Hoozemans MJM, Van der Beek AJ, Blatter BM, Van Dieën JH. *The predictive validity of the RSI QuickScan questionnaire with respect to arm, shoulder and neck symptoms in individual computer workers. Submitted.*

Speklé EM, Hoozemans MJM, Blatter BM, Heinrich J, Van der Beek AJ, Knol DL, Bongers, PM, Van Dieën, JH. *Effectiveness of a questionnaire based intervention programme on the prevalence of arm, shoulder and neck symptoms, risk factors and sick leave in computer workers: A cluster randomised controlled trial in an occupational setting. BMC Musculoskeletal Disorders. 2010;11(1):99.*

Speklé EM, Heinrich J, Hoozemans MJM, Blatter BM, Van der Beek AJ, Van Dieën JH, Van Tulder MW. *The cost-effectiveness of the RSI QuickScan intervention programme for computer workers: Results of an economic evaluation alongside a randomised controlled trial. BMC Musculoskeletal Disorders. 2010;11(1):259.*

Other publications

Articles in Dutch journals

Hoozemans MJM, Visser B, Huysmans MA, Speklé EM, van Dieën JH. *Spierbelasting en RSI. Werk, Houding & Beweging. 2007;12(1): 4-11.*

Hoozemans MJM, Visser B, Huysmans MA, Speklé EM, van Dieën JH. *Spierbelasting en RSI. Geneeskunde en Sport. 2005; 38(1): 7-13.*

Hoogendoorn E, Speklé EM, Copier WJM. *STECR Werkwijzer ABBE-RSI: Aandoeningen Bewegingsapparaat Bovenste Extremiteiten. Tijdschrift voor Bedrijfs- en Verzekeringsgeneeskunde. 2004;12(6):188-9.*

Conference proceedings

Speklé EM, Hoozemans MJM, Van Dieën JH. *Concurrent validity of the symptom questions of the internet-based RSI QuickScan in computer workers. Proceeding of the 7th International Scientific Conference on Prevention of Work-Related Musculoskeletal Disorders (PREMUS 2010); Angers, France; 2010. CD-rom.*

Speklé EM, Heinrich J, Hoozemans MJM, Blatter BM, Van der Beek AJ, Van Dieën JH, Van Tulder, M. *Economic evaluation of an intervention programme on exposure to risk factors, prevalence of arm, shoulder and neck symptoms, and sick leave in computer workers. Proceeding of the 7th International Scientific Conference on Prevention of Work-Related Musculoskeletal Disorders (PREMUS 2010); Angers, France; 2010. CD-rom.*

Speklé EM, De Jong L, Buster R.
Lichaamstrillingen bij buschauffeurs - Interpretatie mogelijkheden van meetgegevens. Nederlandse Vereniging voor Ergonomie, 5e congres Ergonomie in Uitvoering: 'topprestaties'; Zeist, The Netherlands; 2009. CD-rom.

Speklé EM, Hoozemans MJM, Van der Beek AJ, Blatter BM, Bongers PM, Van Dieën JH.
Test-retest reliability and concurrent validity of a questionnaire on the ergonomic aspects of the computer workstation. VUmc Wetenschapsdag; Amsterdam, The Netherlands; 2008. p.94.

Speklé EM, Hoozemans MJM, Van der Beek AJ, Blatter BM, Bongers PM, Van Dieën JH.
Test-retest reliability and concurrent validity of a questionnaire on the ergonomic aspects of the computer workstation. In: Helgadóttir B (ed). Conference Proceedings NES 2008 Abstracts: Ergonomics is a lifestyle. Reykjavik, Iceland; Gutenberg; 2008. p.81.

Speklé EM, Hoozemans MJM, Kraaijeveld RA, Van der Beek AJ, Blatter BM, Bongers PM, Van Dieën, JH. *Can the RSI QuickScan validly predict the development of upper extremity symptoms? Book of abstract PREMUS 2007 - The 6th International Conference on Prevention of Work-Related Musculoskeletal Disorders; Boston, USA; PREMUS, 2007. http://www.premus2007.org/conference-proceedings.htm.*

Blatter BM, Speklé EM, Heinrich J, Hoozemans MJM, Van der Beek AJ, Bongers PM, Van Dieën, AJ. *Effectiveness of the 'RSI QuickScan': A preventive program on arm, neck and shoulder symptoms for office workers. Book of abstract PREMUS 2007 - The 6th International Conference on Prevention of Work-Related Musculoskeletal Disorders; Boston, USA; PREMUS, 2007. http://www.premus2007.org/conference-proceedings.htm.*

Speklé EM, Hoozemans MJM, Van der Beek AJ, Blatter BM, Van Dieën JH, Bongers PM.
RSI: validation of a questionnaire on occupational exposure and health complaints. 30ste WEON symposium "Preventie en Interventie"; Wageningen, The Netherlands; 2005. p.97.

Speklé EM, Hoozemans MJM, Van der Beek AJ, Blatter BM, Bongers PM, Van Dieën JH.
Validation of a questionnaire to assess risk factors and complaints related to upper extremity disorders. 18th International symposium on Epidemiology in Occupational Health (EPICOH); Bergen, Norway; Occupational and Environmental Medicine 2005;62:e3.

Speklé EM. *Workstation design. In: Johansson G (ed). Conference Proceedings of the Nordic Ergonomics Society Annual conference 1998 "Communication at work"; KFS AB; Lund, Sweden: p. 243.*

Speklé EM. *Self-reported musculoskeletal symptoms among off-/onshore workers in a Norwegian oil-drilling company – a descriptive study. Proceedings of the 13th Triennial Congress of the International Ergonomics Association "From experience to innovation"; Tampere, Finland: Finnish Institute of Occupational Health; 1997. 4: p. 402-404.*

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Dankwoord

Na het schrijven van het proefschrift rest het dankwoord en heb ik veel om dankbaar voor te zijn.

Blij verrast was ik toen Jaap van Dieën mij vroeg of ik geïnteresseerd was om mijn onderzoek naar de RSI QuickScan, dat ik in het kader van de postdoctorale beroepopleiding Ergonomie bij arbeid had uitgevoerd, wilde voortzetten in het kader van een promotie onderzoek. Dat wilde ik wel en met de steun van mijn gezin, de Vrije Universiteit, Arbo Unie en de Stichting Arbo Unie Nederland ben ik in 2004 gestart met het opzetten van het onderzoek. Bij de totstandkoming van dit proefschrift zijn veel mensen betrokken. Ik wil graag de volgende mensen en organisaties in het bijzonder bedanken voor hun bijdrage:

Bedrijven en deelnemers aan de verschillende onderzoeken

de deelnemende organisaties en hun vele werknemers. Zonder hun medewerking, geen data en dus ook geen onderzoek.

Begeleidingscommissie

mijn "All Stars" begeleidingscommissie, die in het begin bestond uit Jaap van Dieën, Paulien Bongers, Marco Hoozemans en Allard van der Beek. Halverwege heeft Pauline zich helaas wegens andere drukke bezigheden teruggetrokken en heeft Birgitte Blatter haar plaats ingenomen. Ik had mij geen betere begeleidingscommissie kunnen wensen. Wekelijks heb ik overleg gehad met Jaap en Marco. Daarnaast zijn we regelmatig met de hele begeleidingscommissie bijeen geweest, wanneer er belangrijke keuzes gemaakt moesten worden. Ik heb veel geleerd van de discussies die we daar hebben gevoerd, maar belangrijker nog is dat ik tijdens het hele project de steun van alle begeleiders heb ervaren.

Promotoren

Jaap, sommige wetenschappers weten veel van weinig, maar jij weet veel van veel. Als initiator van dit project, samen met Paulien en als eerste promotor heb je een zeer belangrijke bijdrage geleverd aan de start en het verdere succes van dit project. Ik heb onze overleggen niet alleen als inspirerend, maar ook als zeer gezellig ervaren. Daarnaast waardeer ik ook dat je begrip hebt getoond voor het feit dat mijn werk bij Arbo Unie soms moeilijk te combineren was met het promotieonderzoek.

Allard, hoewel je een verdieping lager bij het VUmc zat, was je voor mijn gevoel nooit ver weg. Je kennis over het beoordelen van blootstelingen en de arbeidsepidemiologie was een belangrijke aanwinst voor dit project. De suggesties die ik mocht ontvangen op de diverse conceptversies van artikelen waren niet alleen helder, maar ook zeer systematisch

uitgevoerd. Een voorbeeld dat ik probeer na te streven, wanneer ik nu zelf stukken van anderen lees.

Co-promotoren

Marco, van alle begeleiders heb ik met jou als co-promotor en 'hands-on' begeleider het meest intensief contact gehad. Ik heb heel fijn met je samengewerkt en veel van je geleerd. Ik kon altijd bij je binnenlopen en dat heb ik ook veel gedaan. Jouw hulp bij alle grote èn kleine zaken is een belangrijke succesfactor geweest voor het slagen van dit project, al zal je dat, bescheiden als je bent, waarschijnlijk ontkennen. Jouw uitspraak: 'Het gaat om wat je kunt en niet om wat je bent', heeft mij moed gegeven en zal ik niet snel vergeten. We houden contact!

Birgitte, ook wij hebben vanaf het allereerste begin veel contact gehad. Jouw grote ervaring met het opzetten en uitvoeren van dit soort veldonderzoeken was onmisbaar. Daarnaast hebben we altijd heel fijn samengewerkt en ik hoop dat er andere projecten zullen volgen.

Promotiecommissie

Leden van de leescommissie (prof. dr. F.J.H. van Dijk, prof. dr. M.P. de Looze, prof. dr. IJ. Kant, prof. dr. S. Taimela en dr. K.B. Veiersted), hartelijk dank voor de beoordeling van het manuscript. Voor de aanwezigheid bij mijn verdediging wil ik graag prof. dr. ir. PM. Bongers, prof. dr. F.J.H. van Dijk, dr. B. Visser, prof. dr. S. Taimela en dr. K.B. Veiersted, bedanken. I would like to extend a special thanks to Simo and Bo for travelling respectively from Finland and Norway, to serve on the opposition.

Arbo Unie

Arbo Unie, toen ik gevraagd werd voor dit promotieonderzoek realiseerde ik mij meteen dat een dergelijk groot project alleen mogelijk zou zijn met de steun van mijn werkgever. Gelukkig had Arbo Unie toen al evidence-based handelen hoog in het vaandel staan en zagen ze direct het nut ervan in, om één van hun eigen instrumenten en interventie programma's wetenschappelijk te laten onderzoeken aan de Vrije Universiteit. Bij Arbo Unie hebben Ed Moolhuizen, Jan Koopman en Dick van der Laan dit promotieproject vanaf het eerste uur gesteund en die steun is later, ook toen het financieel minder ging, voortgezet onder leiding van Wilma Hogers, Tjitte Wever, Jan Schreurs en Margriet Tiemstra. Zonder deze steun en de financiële bijdrage van de Stichting Arbo Unie Nederland, zou het onderzoek niet mogelijk zijn geweest. Dank ook aan alle collegae die door de jaren heen interesse hebben getoond voor het onderzoek.

Universiteit en Faculteit

De Vrije Universiteit en in het bijzonder de faculteit der Bewegingswetenschappen, heeft mij onder leiding van Peter Hollander en later Peter Beek met open armen ontvangen. Ook wil ik Olga Jukema, Solveig Lund, het secretariaat en alle andere medewerkers in het bijzonder bedanken voor de genoten gastvrijheid.

Anderen

Judith Heinrich, je hebt een belangrijke bijdrage geleverd aan het (kosten-) effectiviteit onderzoek en de analyses voor het ZonMw rapport. Je systematische werkwijze is een voorbeeld voor mij. We hebben regelmatig gezellige autoritten gemaakt om de diverse deelnemende bedrijven in het land te bezoeken. Onze tocht naar de gemeente Dantumadeel, inclusief autopech en het bezoek aan de garage waar je werd aangesproken met mevrouw Speklé, zal ik niet snel vergeten.

Maurits van Tulder, voor de begeleiding bij het kosten-effectiviteit en kosten-baten onderzoek.

Dirk Knol, voor de statistische ondersteuning bij het effectiviteitonderzoek.

Judith Bosmans, voor de hulp bij de kosten-effectiviteit en kosten-baten analyses, in het bijzonder bij het 'bootstrappen'.

Hein Urbach, helaas veel te vroeg overleden, maar je mag niet in dit dankwoord ontbreken. Je was een goede vriend en ik moet nog vaak aan je denken. We hebben het over van alles gehad en ook over mijn promotieonderzoek, waar je altijd zeer enthousiast over was. Jammer dat je er niet meer bent om het sluitstuk van dit project mee te maken, maar in mijn gedachten ben je er zeker bij.

Paranimfen

Marcel, mijn grote broer, wat fijn dat je na mijn huwelijk ook nu weer naast mij staat bij deze mijlpaal.

Rutger-Jan, oud huis- en clubgenoot, we hebben al heel wat mooie tijden met elkaar beleefd en ik hoop dat er nog vele zullen volgen.

Familie en vrienden

Dank aan alle vrienden en familieleden die met enige regelmaat hebben geïnformeerd, hoe het ervoor stond met het onderzoek en de promovendus.

Lieve ouders, hartelijk dank voor jullie aanmoediging tijdens dit project en voorgaande studies. Jullie jarenlange vertrouwen in mij, heeft mij het zelfvertrouwen gegeven om dit soort projecten aan te durven gaan. Het Engels dat ik leerde tijdens mijn jaar in Amerika is mij ook nu weer van pas gekomen.

Lieve Ingmar en Eline Fleur, hoewel ik mij altijd heb voorgenomen om jullie zo min mogelijk te laten merken van dit project, vrees ik dat ik daar niet helemaal in geslaagd

ben. Maar weet; mijn weekenden achter de computer zijn voorbij! Nu het werk bijna gedaan is hoop ik dat jullie net zo trots op mij zijn, als ik op jullie.

Lieve Margriet, ondanks dat het voor jou niet hoefde, heb jij mijn wens om een promotie-onderzoek te doen vanaf het prilste begin tot het einde volledig gesteund. Bedankt voor alles. Je betekent de wereld voor mij en ik had mij geen betere vrouw kunnen wensen.

Work-related arm, shoulder and neck symptoms have been known for centuries and are still highly prevalent, especially among computer workers. The costs of these symptoms, both from a health and economic perspective, are high. In an attempt to reduce these costs organizations are implementing various interventions aimed at the prevention of arm, shoulder and neck symptoms. One frequently used intervention is the RSI Quick-Scan intervention programme for computer workers. In this dissertation, the reliability, consistency and validity of the RSI QuickScan questionnaire and the (cost-) effectiveness of the RSI QuickScan intervention programme are investigated. The dissertation is concluded with a general discussion of the main findings, methodological considerations and recommendations for occupational health practitioners and future research.

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